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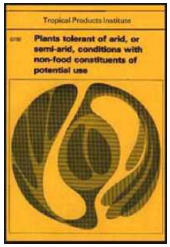
'i Plants Tolerant of Arid, or Semi-arid Conditions and with Non-food Constituents of Potential Use (NRI)

B *(introduction...)*



1! Acknowledgements H Introduction

D Section 1: List of plants tolerant of arid or semi-arid conditions with non-food constituents of potential use Q Section 2: References

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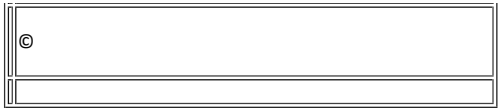

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+ B *(introduction...)*

1! Acknowledgements H Introduction

D Section 1: List of plants tolerant of arid or semi-arid conditions with non-food constituents of potential use Q Section 2: References

J. B. Davis, D. E. Kay and V. Clark

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Plants Tolerant of Arid, or Semi-arid Conditions and with Non-food Constituents of Potential Use (NRI)

(introduction...)

Plants Tolerant of Arid, or Semi-arid Conditions and with ...

Q Acknowledgements II Introduction

Q Section 1: List of plants tolerant of arid or semi-arid conditions with non-food constituents of potential use D Section 2: References

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Institute, Dr G. E. Wickens of the Royal Botanical Gardens, Kew and Mr William Gardener, FLS.

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'i Plants Tolerant of Arid, or Semi-arid Conditions and with Non-food Constituents of Potential Use (NRI)

B *(introduction...)*

G Acknowledgements II Introduction

Q Section 1: List of plants tolerant of arid or semi-arid conditions with non-food constituents of potential use Q Section 2: References

Introduction

In recent years there has been considerable interest in using more productively the renewable natural resources of the arid and semi-arid zones which make up almost 40 per cent of the Third World's land surface (Miegs, 1953; Paylore and Greenwell, 1979; UNESCO, 1979). This report is an attempt to bring together basic information concerning plants which are reported to tolerate arid, or semi-arid, conditions and which have, or might have, potential as raw materials for industrial, i.e. non-food, use.

The information has been presented in tabular form for convenient reference. The resulting tables list alphabetically 298 species which have been reported by various authors, (for example, Arnon, 1972; Chopra et a/., 1960; Cruse, 1949, 1959, 1973; Duisberg and Hay, 1971 and Krochmal et al., 1954) to tolerate arid, or semi-arid, conditions and which yield one or more of the following commodities:

(i) Essential oils, for use in flavourings, fragrances, etc;

(ii) Fibres and cellulosics;

(iii) Firewood;

(iv) Gums and resins, for use as adhesives, but including those which may be used in foodstuffs;

(v) Latexes—for use as substitutes for Hevea rubber and as sources of hydrocarbon fuels;

(vi) Oilseeds—non-food uses, i.e. technical oils used in surface coatings for lubrication, etc;

21/10/2011

(vii) Pesticides;

(viii) Pharmaceuticals—particularly as a source of established drugs or their precursors;

(ix) Tanning materials;

(x) Waxes.

Generally food and forage uses have been excluded although such uses are occasionally mentioned where it seems appropriate to do so. In addition, although firewood continues to be the most important source of fuel for cooking and heating in most Third World countries and its collection in sufficient quantities one of the most pressing daily problems in arid areas and one of the major reasons for their devegetation, little emphasis has been accorded to firewood sources in this report as it was known that a detailed compilation by the National Academy of Sciences in the USA was being

undertaken. The compilation was published (National Academy of Sciences, 1980) and those species mentioned therein, but which had not been included in the preliminary draft of this report, have been added, but without comment and denoted by the suffix f.

The headings used in the tables are largely self-explanatory but the following comments may be appropriate. In the first column the botanical nomenclature used follows closely the Index Kewensis and its Supplements and only the more common vernacular names are given. Information given under columns three and four, Potential and Constraints can be considered as positive or negative attributes applicable to each listed species and its possible exploitation in the future. Where a large number of species have certain properties in common, for example the Euphorbias, Opuntias and Yuccas, their common aspects have been drawn together in the form of general notes rather than repeated under each individual entry.

In all entries only a few key references have been quoted in an attempt to keep the numbers manageable. Nevertheless, the reference list which constitutes the second section of the report should prove a valuable bibliography for the many technolgists, scientists and economists who are interested in developing the plant resources of the arid and semi-arid regions.

The report should be regarded as a working document rather than a final definitive work and it is hoped that it will be of value in the following ways:

(i) as a convenient assemblage of data on each of the species listed;

(ii) as a means of identifying gaps in knowledge and hence indicating the possible direction for new research;

(iii) as a basic document from which it may be possible for scientists, technologists, agriculturalists and economists to select a proportion, say 1 in 10, of the species listed as being worth exploring further.

'i Plants Tolerant of Arid, or Semi-arid Conditions and with Non-food Constituents of Potential Use (NRI)

B *(introduction...)*

1! Acknowledgements II Introduction

D Section 1: List of plants tolerant of arid or semi-arid conditions with non-food constituents of potential use Q Section 2: References

Section 1: List of plants tolerant of arid or semi-arid conditions with non-food constituents of potential use

Name(s)/Distribution	Current/past uses	Potential	Constraints	Citation data
t. *Acacia decwrerts* (Wendl.) Willd. (Wattle) Australia, S, and E. Africa	Ten-year old trees yield 20-25 kg of bark, a widely used taming material. [One variety Ivar. *mottis; = A. mearnsii)* it one of the three major commercial sources of vegetable tanning material]. Wood used for paper pulp.	Bark contains 35% tannins.	Natural tanning materials generally facing severe competition from synthetic tannins.	Ouisberg and Hay, 1971 Isenberg, 1956 Kidder and Finney, 1950
2, Acacia nifotica Delile; syn,	Source of *a* water-soluble gum similar to gum arabic. In India used	Gum exudes from wounds in the bark, yielding from about 100—800 g per tree per year. It is a galsctoaraban	Gum slightly inferior to genuine gum arabic («e entry no. 3). Tanning material	Anderson, 1977 Ayensu, 1979 Chopra *eta!,,*

A. arabica ILam.) Willd. ex Del. *' (Babul) Indigenous to SE, Pakistan (Sind), the Deccan (India), tropical Africa; also found Arabian Peninsula. Natal Egypt.	for timber, tanning material, fodder.	which on hydrolysis yields l-arabinoie and d-jalactose. Bark contains about 12% tannins, seeds 12-19%. Extract of bark showns CNS activity.	produces a dark leather with a tendency to crack.	1960 C.S.I.R. India, 1948 George, 1977
3. *Acacia senega!* (L.} Willd. [1] (Kuitfut) Subtropical arid and semi-arid regions from Delhi westwards to VV. Africa; abundant in Sudan, Senegal.	Principal commercial source of gum Arabic; widely used in the food, pharmaceutical, confectionery and paper industries. Seeds relished as a vegetable in india; leaves, etc. used as fodder. Second largest cash crop in the Sudan, the world's leading producer.	Withstands drought and high temperatures, yield of gum increases with aridity. Gum almost odourless with a blared taste, high in gaiactans. Almost completely soluble in an equal weight of water, to give a translucent, viscous, slightly acid solution. Roots of tree protect soil from erosion.	Faces competition from babul gum *{see* entry no. 2), guar, locust bean, tragacanth, agar and modified starch gums. Competitive position in the Sudan partly dependent upon cheap labour. Tapping the tree said to be an unpleasant task.	Adamson and Bell, 1974 Anon, 1979a Chaudhri and Saleem, 1962 CSIR India, 1948 San and Bansal, 1979 Tevvari, 1979 Wiekens in Davis, 1978a
4. *A chi Has fragramissima* (Forssk.) Schultz Bip. M. Africa. Middle East.		Possible source of an essential oil: leaves contain 0.83% (w/v; fresh-wt. basis) of a pale yellow, aromatic oil, containing a-pinene, d-myrcene, sabinene. l-tinalool, i-terpineol, eugenol, carvacrol, ethyl n-amyl ketone. n-hex-3-en-1 -ol and the	CiJ-hex 3-en-1-yl acetate can be p repa red sy n th et ic al ly.	Opdyke, 1975 Shalabv and Richter, 1964 Zaitschek, 1953

		corresponding awtate c/s-hex-3-en-1-yl acetate (used in fragrances in USA).		

*** Several other *Acacia* species are also found growing wild in N. Africa and are tapped for gum. which is used 1c adulterate true gum arabic. The species include: *A. gtaucophytte* A. Rich., *A. abysswica* Benth., *A. atbida* Delile, *A. leyai* Del He, A sftnwoMW A, Rich., and *A. ehrenbergiana* Hay re (A *atbida* Dehle recently planted extensively in Chad where it is said to have greatly bene fitted the rural economy' <Bren0n m Davis I978ajy. *Acacia* spp. can atso be used as a source of firewood (e.g. in addition to entries *7* and 3. the National Academy of Sciences 1980 hit I *see* Introduction] mentions A *bricfiysttchy** Binth. *A. camb^ei* R. T. Bak., A *cycfops* A. Cunn. ex G. Don, A *satfgna* (LabilM H, Wendl., *A seyaf* DeL, A *rcrrihs* (Fornk.) Hayne) and charcoal (and for browse) and, be.ng leguminous, fix nitrogen. [f] denotes a potential firewood source Introduction)**

List of plants tolerant of arid or semi-arid - Part 1

Constrai nts

Potential

Citation data

Current/past uses

NamelsWDistribution

5. *Achillea safitolina* L,

Middle East, particularly the Libyan Desert.

6. *Adhatoda vasica* Nees [f]

[For *Agsthcsma* sp,, see entry no. 571

7. *Agave americana* L.*

(Century plant)

Native to deserts of SW. USA and Mexico, but now found in India, Africa and the Middle East.

S. *Agave atrovirens* Karw.

(Maguey)

Native to Mexico where it thrives in the semi-arid severely eroded lands of the central region,

9, *Agave atrovlrens* Karw. var. *salmiana* (Otto ex Salm-Dyck) Trelease, syn. *A. satmiana* Otto ex Salm-Dyck

Mexico

Used by the Bedouins medicinally.

Sap fermented to produce the alcholic beverage, pulque.

Used to produce the alcoholic beverage mezcal (2 m litres p.a. in 1960) by cooking the centre portion then fermenting; fibre said to be produced as a byproduct.

Source of alcohol: utilised extensively for production of the beverage pulque.

Possible source of an essential oil: air-dried flower heads yield 0.95-1.02% yellowish-green, aromatic oil, containing atulere-forming compounds. Santolin and santolinol isolated from flower heads.

Juice of mature plants contains sucrose, glucose and mannitol. Possible source of sapogenins: leaves from Texan plants contain 0.04—0.30% hecogenin, Indian 0.065%. Other sapogenins isolated from the leaves include gentrogenin, chlorogenin (?), rockogenin (?). Possible source of paper pulp,

In Mexico, Patrona de Maguey (National Maguey Commission) established to sponsor research on cultivation, crop improvement and utilisation of the products. Said to contain diosgenin (queried by Blunden *et a!.,* 19781; and apparently, vitamin B12 — an essential and relatively rare vitamin.

Production increasing in Mexico, where establishment of nurseries has permitted some selection of stocks. R and D being carried out on technical aspects of processing and handling pulque, Leaves contain hecogenin, its 4-dehydroderivative, and gentrogenin.

Plants normally 8-10 years Old before being used for pulque production in Mexico. [1]

Haddad eraA, 1960 Khafagy and Fatatry, 1969 Khafagy and Fatatry, 1970 Zaitschek. 1953

Blunden *et al.,* 1978 Oyisberg and Hay, 1971 Isenberg, 1956 Marker et *af.,* 1943 Sanchez-Marroqufn and Hope, 1953

Singh and Pereira, 1964 Wilkomirski et *al..* 1975

Ayensu, 1979 Duisbergand Hay, 1971 Hernandez, 1970 SSnchez-Marroquin and Hope, 1953

Blunden *et al.,* 1978 Hernandez, 1970

[f] denotes a potential firewood source (see Introduction}

*** The *Agave* genus includes a number of species native to arid/semi-arid regions but only the more important are listed. The sapogenin content of many other *Agave* spp. has also been recorded by Blunden era/., 1978, 1880 (but mainly on plants grown under temperate conditions),**

***■ One of the main constraints to the utilisation of all *Agave* spp. here listed is finding a species which both produces a good-quality fibre at a reasonable rate and an economic concentration of hecogenin (free of tigogenin contamination), or other sapogenin which can be used as a steroid precursor (i.e. diosgenin, smilsgenin or sarsasapogenin), for extraction from the wastes (cf. Correll *et a!.,* 1955, p. 360**

and Coppen, 1979).

List of plants tolerant of arid or semi-arid - Part 2

Current/past uses

Potential

Constraints

Citation data

Name(s)/Distribution

10. *Agava fotircroydes* Lem.

(Henequen, Yucatan sisal I

Wide range of adaptation in Mexico, where in 1970 there were 200,000 ha. Also grown in Cuba, Honduras, Nicaragua. Grows in al most-arid to sub-humid areas.

11. *Agave techugutlla* Torr.

(Ixtle, Tampico fibre, tula,

Mexican fibre}

Wild plant of the arid limestone mesas and hillsides of Mexico and SE, Arizona, Vu, Texas and S. New Mexico.

Source of a leaf fibre similar to sisal which is used mainly for agricultural twines but also for cordage, upholstery-padding, floor-coverings. Waste from cordage used for paper. Important crop in Mexico where fibre production in

1975 was 139,000 tonnes.

Leaves utilised for fibres used for seeking, upholstery tow, brushes and cordage but particularly good as brush-making fibre as fibres are stiff and easily bleached. Broken fibres used for pasteboard. Source of sapogenins. Stem, root fragments and leaf debris (from fibre extraction) used as a soap substitute in Mexico; stem also used as a fish poison and as roofing material.

Leaves contain 3—4% fibres, each plant yielding about 2 kg dry decorticated fibre. The leaf waste contains 2% wax (of m.p. 91-92°C), hecogenin (trace up to 0.4%L tigogenin I trace up to 0.1%), diosgenin and gentrogenin. Waste also a possible source of alcohol by fermentation. Considerable research dona on by-products in 1940s.

Fibres 20—45 cm in length, ultimate fibres 0.4—2.2 mm. Leaves yield about 1% smilagenin on a dry wt. basis along with diosgenin. tigogenin, gentrogenin. Roots yieid 1.0% sapogenins (20% gitogenin, 80% smilagenin), green fruit 3.7% hacogenin, and seed 1.5% sapogenins (70% hecogenin + 30% manogenin). Contains a pigment thought to be hypercin, or a very similar compound.

Fibre production only starts when plants are 5—7 years old (but lasts for about 15 years K Meed to reorganise and modernise the processing industry and to develop new products. Convenient and economic method of removing the unwanted tigogenin from the hecogenin/tigogenin mixture needed. [r]

Attempts to industrialise crop for fibre in the USA failed in 1950s. Mexican production has shown a downward trend, due to competition from synthetics, and the industry is dependent upon cheap labour. Unpleasant to handle, juice liable to burn skin, Attempts to develop mechanical decortication have had little success (however the fibre still has considerable local (bartering) Importance for the rural poor of N. Central Mexico — and some is still exported I.

Regarded as an unwanted weed in parts of Texas. Plant takes 8 — 10 years to reach maturity then flowers and dies. *

Blunden *et al.*. 1978 Cruse, 1959 Duisberg and Hay, 1971 F AO, 1976a Gentry, 1972 Hernandez, 1970 Isenberg, 1956 Johnson, 1977 Kirby, 1963

Mesa and Villanueva, 1948 Mier and Teran, 1957 Monroe ora/., 1965

Bender, 1963 Benson and Darrow, 1944 Blunden *et at.*. 1978 Cruse, 1959 Cruse, 1973 Duisberg, 1952a Duisberg and Hay, 1971 Hernandez, 1970 Johnson, 1977 Kirby, 1963 Pennington, 1958 Sheldon, 1980 Wall and Fenske, 1961 Wall *et at.*, 1962

12. *Agave mescal* K, Koch Cultivated in Jalisco, Mexico,

Used to produce tequila and allied alcoholic beverages.

Possible source of sapogenins and fibre.

Cruse, 1959

List of plants tolerant of arid or semi-arid - Part 3

[r] *Sea* footnote * to entry no. 7.

Current/past uses

Potential

Constraints

Citation data

Name|s)/Distributdor

13. *Agave pa!meri* Gngelm.

(Palmer agave, mescal, century plant) Widely distributed in SE. Arizona, SW. New Mexico and the Sonora desert (California/SW. Arizona!,

14. *Agave protrtontorii* Trelease SW. USA. Mexico.

15. *Agave schottii* Engelm.

(Schott agave, amole, soso)

Abundant in S. Arizona, New Mexico, the Sonora desert (California/SW. Arizona) and Mexico.

Leaf fibre has been used locally (for ropes). Centre stem after baking is used for food and also to produce alcohol (see entry no, 8(.

U$ed in Mexico as a soap substitute andfijh poison.

Species might have possibilities as a source of fibie and alcohol (for use as a fuel or a feedstock for chemicals).

Possible source of fibre and sapogenins: sapogenin content reported as: 0.2-0.7% hecogenin, 0.1% tigogenin and trace of msnogenin. Has been suggested that it could be developed as a dual-purpose (fibre/ sapogenins) crop in Mexico, in place of *A. fourcroydes* and *A, zaptipe.*

Possible source of sapogenins: seeds contain 1,7% hecogenin; leaves 0,6-1.2% chlorogenin (?) and 0.3% tigogenin (?)

(also (?) smilagenin and gitogeninl.

Plants are not ahundant **and** rate of growth is slow, so harvesting likely to be costly; **in** contrast to some other ***Agava*** spp., little or **no** sapo**genins** reported in the leaves.t

Bah re and Bradbury, 1990 Benson and Darrow, 1944 Gentry, 1972

Correll *et at.,* 1955 Wall *eta/.,* 1954

Benson and Darrow, 1944 Gentry, 1972 Pennington, 1950 Wall and Fenske, 1961 Wall *etaL,* 1955

16. *Agave sisalana* Perrtne ex Engelm. Drummond & Prain (Sisal)

Originated in Mexico, but now grown commercially in E. Africa, Brazil, Haiti, Venezuela, etc.

Source of the most important natural hard fibre — sisal (has high breaking strength and low extensibility); used for twine cordage, sack making, upholstery padding, carpets, handicrafts, particle board, paper pulp, carbonised fibre, etc. Wastes from fibre extraction used as a source of hecogenin (for steroid production! and a wax car also be obtained.

Hecogenin content of the leaves varies with site and age of the plants (0.6—1.3%). Tigogenin, oeotigogenin, sisalagenin, gloriogenin, diosgenin, gentrogenin, and yamogenin also detected in leaves. Hybrids developed in E. Africa for improved fibre production (but have a lower hecogenin content).

The plant requires irrigation for maximum fibre yields when grown in arid or semi-arid areas

— then yield of fibre is about

3.5-4%. Competition from synthetics, particularly polypropylene for baler twine, very serious; is a need to develop new outlets for the fibre. +

Blunden *et a!.,* 1974 Btunden *et &!,,* 1975 Cruse, 1959 Cruse, 1973

Duisberg and Hay, 1971 Evenari and Keller, 1956 Isenberg, 1956 Lock, 1969 Spensley, 1956 TP I, 1975

Possible source of hecogenin: 2.5% reported in leaves - the highest found (by 1955) in any species.

17. *Agave scbria* Brandegee var, *foseana* (Trelease) I. M. Johnstone; syn. ***A. roseana* Trelease Me* ico**

Correll *et at.*. 1955

List of plants tolerant of arid or semi-arid - Part 4

Name(s)/Distribution

Current/past uses

18. *Agave tequilana* Weber" (Mescal, chino azut)

Mexico,

19. *Agave vera-cn/i* Mill.; syn. *A. hirida* Ait.

[East Indian agave)

Probably a native of Mexico, but naturalised in Asia, particularly India.

20, *Agave vilmonntana* Berger Mexico.

21. *Agave zapupe* Trelease Mexico.

22, *Ajuga iya* (L. I Schreb. (Herb ivv, musky bugle) Egypt, S. Europe.

Used to produce (in the same way as mezcal. *see* entry no. 8) the alcoholic beverage tequila; fibre can be produced as a byproduct.

Source of fibre, fructose, sapogenins, paper pulp, alcohol. Pilot-plant scale production of fructose from the stems developed in India giving yield of about 10% from stems; i.e. about 8.75 tonnes of fructose syrup per hectare.

Traditionally used as a soap substitute.

Used as a minor source of henequerviike fibre in Mexico.

Analysis of centre part of plant utilised for production of tequila; water, 60-70%; fibre, 11-12.5%; polysaccharides (mainly inulin), 14.3—24.1%; sugars, 1.0—1.5%; ash, 2.43.9%. Fibre softer and finer that that from *A. fourcroydes.* Production of tequila has increased in recent years. Also contains diosgenin and other sapogenins {and ? vitamin 8*12'* see entry no. 8).

Leaves yield 1.5-2.5% coarse fibre. Stem rich in polyfructosans. Leaves contain 0.1% hecogenin and 0-01% 9 (11)-dehydro-hecogenin; tigogenin also present.

Green leaves contain 1%, or less, sapogerins (smilagenin 80%), mature leaves (7—8 years) 3—4,5% sapogenins. Considered to be a promising economic source of smilagenin; but not utilised commercially (1971J.

Leaves contain hecogenin, tigogenin, gentrogenin.

Ecdysterone (0.012%, after purification), a related C2g compound (0.11%), and a small quantity of cyasterone (all insect-moulting hormones) isolated from plant extract. Crude extract from plant said to have anti-mglarlal activity also.

Ayensu, 1979 Duisberg, 1952b Duisberg and Hay, 1971 Sanchez-Marroqum and Hope,

1953

Cruse, 1959

Gedeon and Kind, 1953 Krishna and Lakshminarayana,

1954

Srinivasan *at al.,* 1954 Subba RaO and Shyama Sunder, 1974

Bender, 1963 Gentry, 1972 Wall *et al.,* 1957

Blunden er *at.,* 1978 Correll *st at.,* 1955 Cruse, 1959

Drar, 1954

Ikan and Havid, 1971 Khafagy *et 3l.*. 1979

Ctieney, 1970 Chopra *et al.,* 1960 Hodge, 1953 Martindale, 1977

Use of both crude aloes and aloin. as purgatives now discouraged due to their irritant action.

Juice contains varying amounts of aloin, a mixture of anthraquinone glycosides; barbalom is the principal constituent. Entry nos. 25, 26 and 27 are the official atoe species. Further species have been used in traditional medicine.

When leaves of many species are cut, a juice exudes (known as 'aloes') which is used as a purgative and externally, to aid healing.

23. ***Albitia tebbeek*** **IL.t Benth. f**

24. ***Aloe*** **spp,**

(Aloes)

A genus of about 130 species of xerophytic plants, mosT being indigenous to E. and S. Africa.

[v]In addition to *A. tequilana* other agaves of the mescal group used to some extent for the production of mescal are: *A. pseuctotequiiana* Trelease. A *palmarls* Trelease, and *A. pas-mute Trelease. t *See* footnote [1]** to entry no. 7.

[f] denotes a potential firewood source (see Introduction)

List of plants tolerant of arid or semi-arid - Part 5

Citation data

Constraints

Potential

Current/past uses

Name (st/Distribution

25. Aloe farox **Miller (Cape aloe^l £, Africa.**

Cheney, 1970 Chopra *era!.,* 1960 Hodge, 1953

See **entry no 26; in addition extraction procedure is very primitive. Severe drought adversely effects yield of aloes. Lower aloin content than *A. vers.***

Aloin content of juice about 10%.

Sole source of 'Cape aloes'.

26, *Aloe perry i* **Baker (Socotrine. or *ZdTiz*** **ibar*alOeSi Found on Socotra llndian Ocean), in E. Africa and the Arabian peninsula.**

27. *Aloe vera* **(L,> Burm. f,; syn. *A barbadensh*** **Miller,**

A. vulgaris Lam.

(Barbados , Curasao-or West Indian aloes)

Thought to have originated in the Mediterranean area, but now widespread in Africa, S, Asia and the more arid areas of the Caribbean.

23, *Ammi majvs* **L,**

(Bishop's weed, Ameel

Indigenous to Egypt, Mediterranean and Ethiopia; also found in India and

S. USA.

Source of Socotrine aloes' of commerce.

The main commercial source of aloes, mast of which is produced in the West Indies I'Cura^ao-aloes). The mucilage remaining after collecting the juice car be **used to make a gel ('Aloe-gel') which is incorporated in certain ointments tor treating burns and in cosmetics.**

Drug plant; source of

xanthotoxin, a furocoumarin

I psoralen) which is a photo-iensitising compound used in suntan lotions and to treat leucoderma iskin depigmentation).

Aloin content of juice a little less than 30%. Socotrine aloes reported to be milder and less irritating than other drug aloes.

Aloin content of juice up to about 30%. The mucilage has repeatedly been investigated for antibiotic activity, but the results have been equivocal and the subject of dispute.

Fully mature fruits contain 0.4% nanthotcxin, (8-methoxy-psoralent, immature green 1.0%, Imperatorin, which **can be** converted **to xanthotoxin, and bergapten (5-methoxy-psoralen and with similar properties to xanthotoxin). also present in fruits. Yield of fruits in India about 1,375 kg/ha. Other psoralens recently delected in the seeds. Such compounds have been used in conjunction with UV irradiation to treat psoriasis fan intractable skin ailment).**

Thorny plants, which makes their harvesting unpleasant; low demand for the products and poor financial return; and aloes' effectiveness as a burn treatment (other than as a simple protective coating) has been disputed.

As for A *perryi*

The crop requires irrigation when grown in Jammu, India (hot, fairly dry climate: around 500 mm/year) and on the other hand is sensitive to waterlogging following storms. Fruit set is irregular so hand-picking is essential. Psoralens can be synthesised. Their medicinal use, either internal or external, can cause serious side effects.

Chopra *st al,*. 196D Hodge, 1953

Anon, 1970a Ayensu, 1979 Cherey, 1970 Chopra era/., 1960 Cruse, 1973 Fly and Kiem, 1963 Hodge. 1953 Leung, 1977 Morton, 1961 Winters *et al*1981

Anon, 1981 Bradu and Atal, 1970 Bridges and Strauss, 1980 Chopra *et si.*. 1960 ivie, 1978 Martindale, 1977 Singh, 1963 Stevptison *et al.,* 1981

List of plants tolerant of arid or semi-arid - Part 6

Current/past uses

Potent ial

Constraints

Citation data

Niame(s)/Distribution

29. *Ammi visnaga* (L.) Lam.; syn. *Daucus vitftaga* L-(Khella, tooth pick)

Indigenous to Mediterranean area.

Cultivated in India.

Used in traditional Arab medicine. Now used as a coronary vasodilator and antiipasmodic, the major active principle being khellin (5. 8-dimethoxy -2-methyl (4', 5',

Anon, 1951b Chopra *et a!.,* 1960 Fairbaim, 1953 Gattefosse, 1952 Mart indale, 1977 Mosig, 1964 □uimby, 1953 Singh, 1963

6. 7) furanochromone) which is extracted from the seeds and used to treat angina pectoris and also asthma. It is said (cf. Mosig) to be'non-toxic'

I but *see* Martindale),

Fruits contain 1% khellin. 0.1 % visnagin (8-desmethoxy-kheilin) and 0.3% khellol glycoside. Also contains an aromatic essential oil. Minor constituents accompanying the khellin (visnadine etc, I also have vasodilatory activity.

For angina pectoris, khellin is not so effective as nitroglycerine and in addition, khellin can now be obtained by synthesis.

30. *Amsonia hirteHa* Standi.

USA - Arizona, S. California, Carolina.

31. *Anabasis aphytta* L.

(Itsegek)

Russian steppes from Caspian Sea east to Turkestan; and Syrian deserts.

32. *Anabasis haussknechtii* Bunge S. Russia, Iran, Israel.

Source of alkaloids, especially ana basing whose sulphate derivative has been used as an insecticide (mainly in S. Russia).

Source of alkaloids, crude extract has been used as an insecticide in S. Russia.

Can yield 2—5% natural rubber and vjas investigated as a source of rubber during World War 11 (when supplies of a *Hevea* rubber were cut off from Malaysia). Recently investigated as a source of petroleum-like feedstock.

Contains up to 12% alkaloids, the most important being anabasine, chemically related to nicotine. Other alkaloids present are aphyllidine and aphylline. Methyl-ansbasine, a derivative of snabasine, is reported to have an invigorating effect on respiration centres.

Leaves contain the alkaloid anabasine.

Alkaloid content varies with stage of growth (most in new shoots) and soils. Anabasine has always been of only minor commerical importance and has now largely been superseded by more up to date insecticides.

See *A. apbyHa*

Buehrer and Benson, 1945 Krochmal era/., 1954 McLaughNnand Hoffmann, 1982

Chopra eta/., 1960 Holman, 1940 Martin and Worthing, 1977 Paris and Oillftmgnn, 1960 Petrov. 1972

Evenari and Koller, 1956 Zaitschek, 1953

33. *Androcytvbium qramineum* I Car, I McBridge

Paris and Dillemann, Perrot, 1936

i960

(Lofout}

Occurs in Sahara cases.

Seeds yield 3.7 g/kg colchicine, bulbs 2.9 g/kg. World demand for colchicine estimated to be about 7 tonnes p.a, (1960), mainly obtained from the autumn crocus *Cotchicum autumnal?* L. Attempts have been made to spread Iqfout over a wider area with a view to utilizing it as a source of colchicine.

List of plants tolerant of arid or semi-arid - Part 7

Current,'pest uses

Potential

Constraints

Citation data

Namelsl/Distribution

34. *Antftemis corufa L.*

(Mayweed, slinking chamomile, dog fennel I

N. and S, America, Australia, Europe.

Dried flowers and leaves reported to be effective against fleas, bed bugs and flies.

In practice, synthetic pesticides generally used, even at local level, tor the purposes mentioned.

Krochmal *et al.,* 1954

35. *Apocyrium cannabinum* L. (Dog-bane, Indian hempl USA a nr) S. Canada

36. *Apodantfopra undulata* Gray (a cucurbit - .fee entry no. 95I (MelonlQco I

Native to SW. USA and Mexico.

37. *Argania spinosa* (L.) Skeeis (Argan tree)

Morocco: Sahara region.

Rhizomes used in traditional medicine as a cardiac stimulant and diuretic. Plant extract used tradilionallv to treat warts. Bark has been used for cordage fibre and whole stem for textile fibre.

Minor oilseed.

5eeds used for making oil which is said to be used for cooking. Husks and fruit used for cattle food. Trunk yields a gum. Timber used for construction,

Rhizomes contain the cardiotonic steroid glycosides apocannoside and cymarin (0.1 5—0.1 7%I, both glycosides of the steroid strophanthidin. Seeds contain 23% oil and 29% protein. Fatty acids: non-conjugd. diene" lasC_{18}),

B3%; non-conjugd. triene [t] (as Cjgl, 10%; monoene fas oleic). 30%, saturated, *2%.* Extracts from rhizomes reported to have similar but slightly inferior cardiotonic action to digitalin ■ and an alcohol ic extract reported to have a significant inhibiting action, also ascribed to the presence of the above glycoside?, against human carcinoma of the nasopharynx fas tested in cell culture). Potential oilseed.

Seed contains about 30% Oil; iod, vai. 160 Isemi-drying); fatty acid composition: palmitic, 13%; stearic, 4%; oleic, 11%; linoleic, 42%: linolenic, trace; punicic (9, 11, 13-octadecatrienoic acid}, 30%. Of interest because of the high punrcic acid content. Has Sarge root containing *22%* starch; iodine affinity s/alue, 5.01 § ; gelatinization temperature I64-67[J]) similar to other cucurbit starches; granules have av. diam. of 17 urn sid resemble tapioca starch in form,

Seeds contain 60.4% oil, 19.4% protein. Oil similar to ol ive oil but with higher I inoleic acid content; no problems in refining. Contains 0.5% sterols, mainly -sitosterol and stitjmasterol (both A51.

Anon, 1966a Caldwell, 1966 Dodge, 1897 Earle *et at,,* 1960b Golab *et* a/., 1959 Krochmal *et at,,* 1954 Kupchan er *at.,* 1964 Martindale, 1977 Trabert, 1960

Zaitseva and Feofilaktov, 1950

Bemiserarf., 1967b Berry et *al.,* 1978a Krochmal *etai.,* 1954

Huyghebaert and Hendrick*,

1974

Jones and Barclay, 1972 Usher, 1974

***" e,g, iinoleic acid ' e.g, linolenic acid**

" sure of the amylose content of thf; starch (if <5, it is relatively low as compared with the other major component, amylopectin - as is typical for root/tuber starches: Berry *et at.,* 1978a; Radley,

1 9GS].

List of plants tolerant of arid or semi-arid - Part 8

Citation data

Constraints

39. *Artemisia absinthium* L.

(Wormwood, absinthe I

N. Asia, Afghanistan westwards to the Atlantic. Naturalised in N. America.

to make soap.

Source of essential oil, formerly the major flavour constituent of absinthe (liqueur) and vermouth (aperitif); also said to have a tonic and stimulating effect on the digestion if given in small amounts.

Seeds yield 22-40% oil; sap. val., 188; iod. val., 120; acid vaL, 3.5; unsap matter, 1.1%. Fatty acids; palmitic, 8%; stearic, 5%; palmitoleic, 2%; oleic, 26%; linoleic, 52%; linolenic, 3%; 'oxy-acids' Ifound to be a mixture of hydroxy-, epoxy-, and in-chain keto-fatty acids) 4%.

Utilised in traditional medicine. Seeds contain a semi-drying oil, utilised as a Originated in Mexico, bu(is now widely |ubrieant *iri* |ndiai for pajn,

manufacture in the USA, and

38. *Argamone mexicafia* L. [Mexican poppy I

distributed in the drier parts of the tropics.

Owing to presence of alkaloids le.g. sanguinarine I, oil is narcotic. Oil sometimes used as substitute for, or adulterant of, mustard or linseed oils. Has been suggested for drier areas of W. Africa, because it is quick-maturing, Whole-plant extract shows anti-viral activity.

Essential oil content of the plant, 0.3%: the chief constituent being thujone. Bitter principles are abtinthin and anabsinthin, dimeric guaianolides (C30 H^Og), Sj-hydroxy-3, 3', 4', 6, 7-pentamathoxy flavane also reported present. The seed oil (33% vj/w) has a high epoxy-fatty acid content (23%), of possible industrial Iplastics) use. Lignans, which sometimes show medicinal activity, found in roots (of specimen growing in temperate region).

Regarded as a noxious weed in some areas notably India. The toxic nature of the oil make; it unwise to recommend it for even non-edible purposes in view of possible misuse, Its more polar constituents settle out on standing.

Thujone and absinthin can cause delirium and hallucinations and so its use as a flavouring agent in now prohibited. Epoxy-fatty acids possibly toxic.

Ayensu, 1979

Bhuian, 1959

Chopra et *si.,* 1960

Coursey, 1964

Gunstone *et a!.,* 1977

Man and Lakshminarayana, 1972

Ayertsu, 1979 Beauhaire ef a/., 1990 Chopra *et a!.,* 1960 CSIR India, 1948 Earle et *al.,* 1960c Greger and Hofer, 1980 Herout et *al.,* 1956 Martindale. 1977 Novotny *etBl.,* 1960 Tunmgnn and Isaac, 1957

40, *Artemisia cina* Berg (Levant wormseed)

Malik and Dubash, 1979 Martindale, 1977 Paris and Dillemann, 1960 Smith, 1950

Native to Russia east of the Caspian Sea (Turkestan) and Iran. Has been grown expet imentally in many other areas,

Dried flower heads utilised as a source of the anthelmintic drug santonin.

Santonin content varies considerably; can reach 4—6%, but with the commercial product normally 2-0-2.5%. Highest just prior to the opening of the flower buds.

Commercial production confined Chopra *et ai,* 1960 largely to Turkestan. Requires CSIR India, 1948 cheap labour for hand-picking and sorting. Harvesting normally done over a period of only 2 weeks. Requires hot, dry summer, but moisture-retentive, fertile soils. Content of active constituent varies widely liee column 3).

Attempts at commercial production outside area of origin have met with little success.

Care required In use of santonin — can cause bad side-effects and even death.

List of plants tolerant of arid or semi-arid - Part 9

Citation data

Potential

Constraints

41. *Artemisia hvrba-s/bn* Asso (Desert wormwood, Barbary santonica)

N. Africa, Midd-e Fast, Iran, Afghan istiin.

42 *Arinmhia inculta* Del. vsr, *faxtflam* (Boissl Taikh Sinai desert.

43. *Artemisia judnica* L. ISheeh, Judean wornrivvQOd} tgypt, Arabian desea.

44. *Artemisia ludoviciana* Nutt subsp *mexicana* [Willd> Keek, syn. *A. mcxicana* Willd.

■,Mexican mL.giwirt, estatiste) SW. USA, Mexico,

Utilised as a source of santonin, and of essential oil. Marketed as ^Barbary santonica^ which used locally as a medicine and as a perfumery material.

Utilised in traditional medicine (against worms), as an insecticide and as a condiment. Traded locally: e.g. dried leaves sold in Egypt to make a medicinal tea and in Sudan sold as *a* condiment.

Although the plant is used in the treatment of (ape-worms, santonin (the expected active constituent: *see* entry no, 401 is said to Ijb often absent from this particular species.

Used in traditional medicine, particularly as an anthelmintic. Source of an essential oil.

Dried flowering branches reported to have santonin See previous entry concerning

content 0.99%, Stigmasterol,^-sitosterol, germacranolides, santonin's toxicity, f lavones, and thymol a ho reported. Essential oil content 0.3-1% (thujone main constituent I; exhibits antibacterial activity - ascribed to the santolina alcohol, an unsat Ciq alcohol, therein.

Plants yield 1.6%. essential oii, thujone being the main constituent.

High content of tannins in flowers; sterols and triterpenes, pipfiritone and derivatives, monoterpenes, etc. isolated from whole plant.

Anthelmintic compound, estafiatin, idenfitied as a sesquiterpenic epoxylactone of the guaiane series. Following compounds identified in the essential oil:

(-) - Q -phellandrene; (+) -iimonene, (-) -^-phellandrene; (-) -camphor; |) -borneol; thymol; carvacrol; eugenol.

Chopra ***ct*** *at,,* I960 **Drar, 1954** Khafagy ***erst.,*** **1971 IVtalik** and **Dubash, 1979 Paris** and **Oillemann, 1960 Segal eta/., 1963 Yashphe *eta!.*. 1979 Zalkow *el at.,* 1980**

Drar, 1954

Osborn, 1968 Uphof, 1968 Tawfik eta/., 1978 Zalkow *et at.,* 1960

Manjarre? and Medina, 1964 S^nche7-Vissca and Romo, 1953 Uphof, 1968

List of plants tolerant of arid or semi-arid - Part 10

Current /past uses

vuiiaudiMi*

45. *Arre/7itsia maritima* L.*; **syn, *A- brevifotia* Roy. (Santonica, sea wormwood} Europe to Mongolia particularly NW. India and Pakistan,**

Principal commerical source of santonin; also car be used as source of an essential oil.

Improved strains have santonin contents up to 4,25%. Wild plants to be of commercial value should have santonin content of 1-2%. In addition,0-santonin (also anthelmintic but weaker than santonin itself) and a bitter principle artermisan also present. Essential oil content, 0.32% (air-dried material); mein constituents being cineole, 21 — 34%; ctpinene, 13—16%; camphor, 12-15%; thujone, 10-12%. Possibility of extracting santonin with the essential oil as a by-product has been studied.

In late 1950s, production in Pakistan was some 1000 tonnes dried plant material p.a. In order to remain competitive, there is a need to develop improved high-yielding strains and more economical methods of harvesting, and to extract the santonin locally. *See* entry no. 40 re santonin's toxic ity.

Chaudhri, 1955 Chopra ef *at.,* I960 CSIR India. 1948 Malik and Dubash, 1979 Nigam and Rao, 1967 Qazilbash, 1942 Qazilbash, 1954 Qazilbash, 1960

46. *Artemisia monospefma* Delile Sahara. Egypt, Saudi Arabia.

47. *Artemisia tridental* Nutt. (Black or common sagebrush) SW. USA.

Used medicinally in EaVPt, especially as an anthelmintic. Also possible source of essential oil.

Used in traditional medicine, as a source of pollen extracts, of essential oil, and also as a fodder plant.

A santonin-1 ike compound, with strong toxic effect on the worm *Ascaris,* isolated. Hence the suggestion it be used as a substitute for the santonin-containing *Artemuia* spp. (e.g. entries 40. 41 etc.) Its use as an anti-spasmodic in the treatment of colic or conditions associated with hypertension also mooted. Essential oil insecticidal; contains furoartemone, a furan compound. Whole plant contains various coumarins etc. The plant said to be particularly good for stabilising sand.

Plant materiel high in fat, 10,5%; protein, 1 1.2%; carbohydrate, 26.3%, Yield of essential oil varies from 0.7% to 3%, the major constituents being a-pinene, cineole, 'tfcterpenes', d-camphor, artemisol, and a monoterpenoid ether (Ciq Hie O). Also a number of sesquiterpene lactones isolated from the plant material.

Although used as a fodder plant, it is sometimes poisonous to sheep and horses. Even cultivated specimens show wide variation in e.g. essential oil content-

Evenari and Koller, 19B6 Hammouda *et at.,* 1978 Sharaf era/., 1959a, b Zaitschek, 1953

Buttkus and Bose, 1977 Durham, 1951 Kinney and Sugihara, 1943 Kinney ef *a!.,* 1941 Krochmal and Krochmal, 1973 Sampson and Malmsten, 1935 Shefizadeh *et at.,* 1971 Welch and McArthur in Davis, 1978c

There is considerable variation in the santonin content of *A. maritima* and some confusion regarding the nomenclature. Some authorities distinguis t yp Kurram, which his a high santonin content, as a separate species *A. kurramensis* Qazilbash.

List of plants tolerant of arid or semi-arid - Part 11

Current;'pan uses

Constraints

Citation data

48. *Afw)<3o donax* L.

(Bamboo reed, Provence cane, caf ri?ol

Native to Mediterranean, but now Widespread in sub-tropics.

49. ***Asdepias erosa*** Torr. **(Milkvueed, hierba lechosa! Mexico, SW USA.**

50. ***Asclepsas subuSata*** **Decaisne I Desert milkweed)**

SW. USA, Mexico.

Source of musical reeds, matting, industrial cellulose and used in basketry; rhizomes used medicinally.

Source of rubber.

Analysis of culms: cellulose, 40-58%; pentosans, 18-34%, lignin, 9-23%, ash, 2—7%. Pharmacologically active indoie-3-alkylamine bases, including bufotenidine and dehyrirobufotenine (narcotics), isolated from rhizomes; **with triterpenes and sterols from leaves. Research on its possibilities as a source of paper pulp has been carried out in a number of countries.**

Hubber content of leaves 2.5—13% Average when grown under cultivation, S.5%. Was investigated in 1930s and early 1940s as a possible source of naturaf rubber in the USA in the event of a shortfall of ***Hevea*** **rubber (but apparently no positive outcome). Recently investigated with** ***A. sttbulata*** **as a source of petroleum like feedstock The seeds of** ***Asctepias*** **spp. usually also contain 1 5-20% of a semi-drying oil similar, but inferior, to I inseed oil -and potentially with similar outlets. Most** ***Asctepras*** **spp. can also be used as a source of paper-making material.**

Rubber content varies from 0.5 to 6,0% in wild plants, with most of it in the new growth; mean 2.8%; under cultivation, 5% in 3- and 4-year old plants. Highest during the dormant period. Can harvest every 3 years by allowing regrowth to take place. Said in the mid-1920sto be the most promising native US plant for rubber production there in the event of shortages of ***Hevea*** **rubber. In addition, 28.5%of bleached good quality paper has been obtained experimentally. Most** ***Asctepias*** **spp, also yield a seed oil** ***{see*** **entry no 49) and some, including** ***A. subu/ata,*** **an oil-like fuel** ***(see*** **entry no. 144); a trial planting of a [1]milkweed' (? an** ***Asctepras*** **sp.; or possibly entry no. 144) has recently been reported.**

Synthetic materials replacing reeds in musical instruments.

Use as a source of rubber presumably not viable except perhaps in times of severe ***Hei/ea*** **shortfall.**

X-ray photographs of typical samples of the rubber do not show the crystal structure characteristic of *Hevea* rubber, implying that it would be of tittle commercial value. Possibility of two sub-species one more xerophytic (with smaller, woody plants) and seems that the yield of rubber may be less from this type. Plant material must be stored in the dark after harvesting Otherwise **rubber content decreases.**

Chaudhuri and Ghosal, 1970 Duisbergand Hay, 1971 Dutta and Ghosal, 1967 Ghosal ef *si.,* 1969 Ghosal *era!.,* 1972 Matzke, 1969 Perdue, 1958

Buchanan a/.. 1978 a, b Krochmal £[*a!.,* 1954 McLaughlin and Hoffmann, 1982 Whiting, 1943

Beckett and Stitt, 1935 Buchanan era/., 1978a, b Buehrer and Benson, 1945 Calvin, 1978

McLaughlin and Hoffmann, 1982 Whiting, 1943

List of plants tolerant of arid or semi-arid - Part 12

51. *Asphodelos aestinJs* Brot., syn. *A- micfocarpus* Salzm. et

Vi vi.

Mediterranean.

52. *As rragatus gummifer* Lab[T] (Tragacanth, astragal, milk vetchl Turkey, Iraq, Iran, Syria, Greece,

53. *Avicennia officinalis* L.; syn, *A tomentosa* Jacq.

(White mangrove)

Salt marshes of India and Middle East, Burma coast, Malayan Peninsula, and islands to the Philippines and parts of S. China.

Tubars used in traditional medicine and as a source of gum.

One of **the earliest gums utilised by man. Now used as a thickener and stabiliser'in foods, in cosmetics, in confectionery manufacture, in pharmaceutical preparations and in textile manufacture**

Various parts used in traditional medicine.

Dry tubers contain 66—65% total sugars and pilot-scale experiments have shown that 21.5—25 litres *oi* alcohol can be obtained per 100 kg dry tubers. Hence a possible commercial source of alcohol (fuel and possible feedstock for manu(acture of chemicals). Tubers also contain 2.7% mucilage (glucose, galactose and arabinosel, j3-sitosterol-(3-D-fJlucoside, and stachydrine; seeds contain 14,8% 'fixed' (fattv) oil containing j3-sitottftrol and jS-amyrin, Possible oilseed.

The gum is formed by the transformation of the cells of the pith and medullary rays into a mucilaginous material. Two forms -*■ ribbon, which is preferred, and flakes. The gum is a complex mixture of polysaccharides containing D-galacturonie acid, galactose, L-fucose, D-xylose, L-arabinose; 30-40% of the gum (namely, the fraction known as tragacanthin, an arabinogalactan) is soluble in water, while the remainder forms an insoluble gel known as bassorin or tragacanthic acid. Plant leguminous, hence enriches soil.

Wood contains 54.7% cellulose and is a possible source of paper putp. Aerial parts have been found to contain lupenone, lupeol, betulinic and ursolic acids (all triterpenes) and (J-sHosterol. Suggested worth investigating as a source of gym id Egypt

Collected from wild shrubs (though commercial cultivation has beer considered in Iran) and is dependent upon cheap labour. Quality and yield affected by climate. Life span about 5 years and cart only be tapped alternate years. Faces competition from Karaya gum and locust bean gum.

The wood chips badly and produces a putp which is not easily bleached.

Drar, 1954 Fell et *si.,* 1968 Ferrari, 1949; 1950 Hammouda era/., 1971 Hammouda *eta!..* 1972 Kampouris and Thomopoulos,

1971

Rizk and Hammouda. 1970

Aron, 1979a

Aspinall and Baillie. 1963a, b Barber, 1951 Gentry, 1957 Howes, 1&49 Lees. 1973

Stauffer and Andor, 1975 Uphof, 1968

CSIR India, 1948 Drar, **1954**

Subramanian and Vedantham,

1974

t Principal species used as a source of gum iragacanth: others included, *adscendens* Bois S., *A, brzchyeentrus* Fisch.,^. *cerasocrenus* Bunge, *A. kurdicus* BoisS., andj4. *microcephalus* Willd.

List of plants tolerant of arid or semi-arid - Part 13

Current/past uses

Citation data

54. *Azadirachta indies* A. Juss,[f]; syn. *Mo/13 azat/irachta* L,

(Meem, margosa. bead tree, Indian lilac}

Native of India; now also found in driflr regions of Africa.

55. *Baccharis sarorhroides* A, Gray (Desert broom)

California and the Mojave desert (Arizona).

Fruits yield an oil used In the manufacture of soap, Bark, leaves and fruit used in traditional Indian medicine and as an insecticide. Extracts of bark recently used in toothpastes, etc. Timber has been used for furniture, construction and fuel when nothing better available. Exudate from bark used as a gum. Sweet exudate obtained from upper branches utilized as a drink, 'neem toddy'. Shells from seeds used as fuel.

Sometimes grown as an ornamental shrub (certain other members of the genus, growing in Arizona, are used medicinally).

Seed kernels yield 50—60%oil: sap. val.. 195-204: iod. val, 68—75; unsap, matter, 0,7—1.7%; fattv acid composition: myristic, 0.1 %; palmitic, 16%; stearic 18%; arachidic, 2%, behenic, 0.5%; lignoceric, 0.2%; oleic, 53%; lincleic, 10%. Oil contains bitter principles (2%, mainly **nimbidin) and foul-smelling sulphur compounds. Nimhidin and related compounds, present in seeds, bark and leaves, have medicinal activity, Azadirachtin recently isolated from the tree and found to have strong insecticidal properties. Grows rapidly. Can be raised successfully as an intercrop. Thrives on poor dry soil,**

Seeds contain 31,3% oil 3rd 23,8% protein; a potential oilseed.

Much research needed; such as on the plant's agronomy, on methods of oil extraction, refining and deodorization, and on the use of the oil as a possible replacement for palm or coconut oils in soap manufacture, further investigation of the therapeutic principles, and of the insecticidal and anti-feedant compounds, also required. Domestication said to be difficult; successfully introduced into Haiiti. Frost-sensitive.

Certain other members of the genus, growing in Arizona, are toxic to livestock.

Coursey, 1964 CSIR India, 1948 Davis, 1978b

Godin and Spensley, 1971 Ketkar, 1976

Lewis and Elvin-Lewis, 1983 Ftadwanstei, 1977 a, b, c, d Radwanski and Wickens, 1981 Thompson and Anderson, 1978 Watson, 192S Williams, 1966

Benson and Darrow, 1944 Jones and Barclay, 1972 Duncan *et* a/., 1957

56. *Balanites aegyptiaca* (L.) Delile; syn, *Ximenia aegyptiaca* L.*.

(Desert date, betu, zachum, heglig, thorn tree, Egyptian balsam, lalob treel

Thought to have originated in the Nile Valley but now widely distributed in Africa and Asia as far as Burma,

Seed kernel of fruit yields an oil. mainly used for soap.

Fruit edible and used for production of alcoholic beverages, and as a cleaning agent, Wood is used for general carpentry work. Roots and bark are sometimes used medicinally {purgative, anthelmintic); bark is source of a strong fibre.

Kernels consist of about 10—12% of the whole fruit, and contain 40—60% oil and 1% sapogenins. Oil is bland, yellow, tasteless; composition variable. Sap. val., 195—204;; iod, val., 88—103; fatty acid composition: palmitic, 19-24%; stearic, 5-14%; oleic, 27-50%; linoleic, 20^40%; hydroxy-dienoic acids also reported. Protein of kernel reported to be high in lysine. Major tapogenin is yamogenin (same outlets, as a steroid precursor, as diosgenin). Fruit pulp contains 40% reducing sugars and about 1% sapogenins (yamogenin and diosgenin), Various groups have investigated the possibility of utlising the seed as a source of oil and commercially useful sapogenins; an attempt has been made to develop a multi-purpose process to utilize the pericarp and seed for production of sapogenins, oil and oilcake.

The plant grows erratically and is thorny. The principal obstacles to commercial exploitation have been the problems of removing the sticky pericarp, of decorticating the nuts, and obtaining adequate, regular.supplies, Sea comments under entry no 111 concerning use of diosgenin as a steroid precursor.

Anon, 1961b Ayensu, 1979

Chantegrel *eta!.,* 1963 Coursey, 1964 Drar, 1954 Earle *et at.,* 1960b Hardman, 1969

Hardman and Sofowora, 1970, 1971, 1972 Heintz *et a!.,* 1965 Misrsefa/., 1975 Morris ef *aL,* 1960 Paroda, 1979 Uphof, 1968 Williams, 1966

Balanites mxburgtiii* (considered a separate sp. by e.g. Uphof, 1968 but a synonym for *B. aegyptiaca* by e.g. Hardman, 1969) also grows extensively in arid zones and contains 0-9--1.4% diosgenin IParoda 1979; Misra *et ai., 1975)

[f] denotes a potential firewood source (iee Introduction)

List of plants tolerant of arid or semi-arid - Part 14

57. *Barosma betuimd* (Berg) Sartl. and Wendl. f* (Buchu)

SW. Cape Province, S. Africa.

58. *Brassica juncea* (L.) Czern. (Indian or brown mustard; leaf mustard)

Probably originated in the drier parts of N. and C. Africa, N, China and SE. Asia. Now found in many parts of Africa, Asia, Europe and America.

59. *Bromefia serra* Griseb (Chaguar moradoj**

S- America, especial Iv Argentina and Brazil.

60. *Brongniartfa alamosana* Rydb. SW. USA, Mexico.

Leaves are the drug buchu, used as a diuretic, stomach tonic, etc. Source of an essential oil used in artificial fruit flavours particularly blackcurrant, the oil being very expensive and in demand in the USA.

Used as a source of edible oil, particularly in Asia; also used as a condiment (increasingly so of latel and medicinally. Leaves used as vegetable. Many different races are cultivated.

Perennial herb. Source of Hctaraguaita fibre, used locally for sacks, and cordage. Was exploited during World War II as a jute substitute.

Leaves contain 2—3% essentail oil; brownish-yellow, partly crystalline at 20°C. Crystals (buchu camphor) are a mono-terpene (Cio) diojphenol, Other constituents include limonene, nrienthene, L-pulegone. Recently the presence of stereoisomers of S-mercapto-p-fnenthan-3-one, plus 120 other constituents reported.

Seed contains 30-42% fixed (fatty) oil, plus varying amounts, up to 2.9%, of volatile oil and about 28% protein. Fixed oil has sap. val., 170-176; iod. val., 106—114. Fatty acid composition: erucic, 18—49%; oleic, 7—22%; linoleie, 12—24%; linolenic, 10—15%: saturated acids, 5%, Volatile oil contains altyl isothiocyanate and related compounds. Including crotonyl isothiocyante. Integrated process has been developed for production of oil, protein meai and tha pungent factor - allyl isothiocyanate.

Possible source of paper pulp.

Seeds contain 34% oil, 27% protein. Sap. val. of oil, 166: iod. val. 129. Fatty acids: (as Cis) non-conjugated triene, 23%; non-conjLigated diene, 15%; conjugated, 3%; monoene (as oleic), 27%. Hence a possible oilseed.

Cultivated on a very limited scale in S. Africa, but seed germination difficult, and the products mostly still obtained ■from wild plants; plants harvested when 4—5 years old. May yield poorly in true arid jone: plants need well-drained slopes with 400—700 mm 116—28 inches) rainfall p.a. Supplies of the essential oil short in early 1970$ but this because interest in the crop had been declining.

May not grow welt in truly arid areas: currently it mostly grown as a rain-fed oilseed crop in SE. Asia and supplementary irrigation is often used. Use as an edible oil would be restricted by the high content of erucic acid (health risk).

Anon, 1974a Blommaert, 1972 Flucketa/., 1961 Gentry, 1961 Kaiser *st al.,* 1975 Klein and Flojahn, 1968 Martindale, 1977

Mustakas *et at,,* 1965a Naqvi and Haq, 1964 Ohlson, 1972 Singh, 1958

Vaughan and Hemingway, 1959 Uphof, 1968

Anon, 1941 Ercilla, 1948 Ercilla, 1949

Earle *et at.,* 1962 Jones and Barclay, 1972

Two other closely related species *B. crenulata* (L.) Hook (oval buchul and *B. serr$tifolia* (Curt.) Wilid. (long buchu) are also utilized to a limited extent as a source of buchu. R V genus *Agathosma,* thus *B. betutina* has become A *betufina* Berg. Pillars and *B. serratifolia* has been merged with *B. crenutata* to become A *crenutata* (L.) nllans. ^

Four other closely related species are also used for fibre (sometimes also known as kareguata). these are *B- balantae* Mez, *6. fastuosa* Lmdl., *B. hieronynrti* Mez and *B. iacirrtosa* (Via t.

List of plants tolerant of arid or semi-arid - Part 15

Current/past uses

Citation data

61. *Butnesis retamo* Griseb. (Cera mimbi, broom wax)

Dry areas of western Argentina.

Source of wax used in polishes (e.g. said to be 'excellent' for shoe polishes), in dyes for leather, printers' ink, pharmaceuticals.

Composition of wax: hydrocarbons, 19.8%; free fatty acids, 33.8%; free alcohols, 7.9%; wax esters, 38.5%. Of the fatty acids around 70% were saturated; 11% hydroxy-acids; 19% unidentified; and 0.4% 'resinous' acids. Potential production of the wax ('Hetamo wax' of 'Cera mimbi') in Argentina in late 1950s reported to be of the order of 1,300 tonnes p a. Used locally arid could have possibilities as. a substitute for carnauba, eandelilla and ouricuri waxes.

Probably local use only: poor market for such waxes.

Lina ef a/., 1958 Tinto and Pardo, 1957

62. *Bulnesia sarmienti* Lor. ex Griseb. (Pau or palo santo, Paraguay lignum) Paraguay, Argentina.

63. *Bursera rwcrophytla* A. Gray; syn, *Elaphrium joruMentis* Kunth

(Torote bianco tree, elephant tree, copal)

SW. Arizona and NW. Mexico (Baja California; Sonora).

A source of the essential oil known as guaiac wood oil, used in perfumery (particularly in soap manufacture) and to make guaiac wood acetate, also used in perfumery. Oil sometimes also used to adulterate Bulgarian and Turkish rose oils. Timber used for fences, construction, etc. Rosin used locally to glaze china, etc.

Bark used as a source of dye and for tanning in Mexico; exudate hardens to form a copal used as incense.

Timber chipping* steam-distilled yield 2.7-3,0% of oil with a pleasant, soft, mellow, rose like odour, sp, gr.

(at 30*C}, 0.967—0.974; optical rotation, -3° to -8°; no (at 20^{c}C), 1.502—1.507; acid no., 0—1.5; ester no., 0—7.5 (98—159 after acetylation); guaiol content, 42—72%. Production in Paraguay in 1973, 75—100 tonnes p.a., exported mainly to the USA. Demand reported to be steady and supplies sufficient to meet it. Attempts have been made to extract the rosin as a by-product in Argentina and to develop its use by the soap and paint industries.

Tree characteristic of very arid areas; has recently attracted attention as *a* possible source of drugs for cancer treatment. Anti-tumour agents isolated and identified as the (closely-related) lignans deoxypodophyllo-toxin and 3—(3, 4, -methylenedloxy beniyll—4—(3\ 4^{f}, 5* -trimethoxybenzyl) — tetrahydrofuran (burseran), ^-sitosterol also reported, Essential oil present in twigs, leaves and fruit; and consists of 30% terpenes (largely 0*t*- and (J-phellsndrenes and tetrahydrocuminic acid) and 9% sesquiterpenes and oxygenated compounds. Fruits also contain 5% of soft yellow wax, m.p. 57°C.

Anon, 1973a Guenther, 1952 Leila and Rique, 1955 Levi-Strauss, 3 952

Benson and Darrow, 1944 Bianchi et *at.,* 1968 Bradley and Haagen-Smit, 1951 Cote er *a!.,* 1969 Duisberg and Hay, 1971 Uphof, 196a

[For *Cactus* spp., see *Qpuntia]*

64. *Caesaipioia gilHesii* Wall, ex Hook.

Benson and Darrow, 1944 Duisberg and Hay, 1971 Perdue and Hartwell, 1969 Ulubelen ef *a!.,* 1967

(Bird of paradise)

Native of Chile and Argentina but now also established in SE. Arizona and S. New Mexico.

A prgteinaceous substance with promising anti-tumour activity isolated from the seeds.

List of plants tolerant of arid or semi-arid - Part 16

Name(sM Distribution

Current/past uses

65. ***Ca/arrui cajan*** **IL.)**[f]

66. ***Calotropis ptocara*** **[Ait.) R.Br. (Akra, alarka, ushar, auricula tree, akund; fruits - apple of sodom)**

Drier areas of Asia, **particularly** India, and Africa (especially Libya): has also been introduced into Australia and NEE. Brazil.

67 ***Capparis tascicularis*** **DC. var,** ***fascictt laris;*** **syn.** ***C. rothii*** **Oliv.**

Sudan.

68. ***Capparrs owta*** **Desf.**

Middle East, W. Asia. N. Africa.

Seeds source of akund floss., used for upholstery stuffing; seeds also contain a semi-drying oil. Bast (inner-bark) fibres extracted in India and used for rope. Source of latex used for tanning and dyeing. Late*, root bark and leaves used medici nal ly in India and Africa. Wood used as source of charcoal. Leaves produce merissa, a native beer in W. Africa. Latex removes hair from hides, and stems are used for making huts.

Fibre length of floss 30—40 mm, diameter 0.04 mm; cellulose content 49%. Seeds contain: protein 34%, oil 17-30% (of which unsaturated fatty acids. 69%); pectin 1.*2%;* also various glycosides. Calotropain, a proteolytic enzyme similar to bromelain and with anthelmintic properties, isolated from the latsx. Cardiac glycosides uscharin (C31H41 NOsS), voruscharin (C31H43NO8S), uscharidin IC29H38Q9). calotropin (CzgH^oOg), calotoxin (C29H40O10), and calactin (C29H40O9) isolated from the latex, Uscharin more poisonous than strychnine. Bemoyllineolone and benroyliso-lineolone isolated from the bark. Process for preparation of uscharin and uscharidin has been patented. Suggested as & possible oilseed crop, also a fibre crop in Egypt Attempts have been made to improve the extraction of bark fibre on a cottage-industry scale in India (by Central Arid Zone Research Instituted: the fibre used to be spun into a very fme Cloth there. Plant easily established in areas of soil erosion: dominant species along Jeddah-Mecca road.

Scope for increased fibre production, especially in India (where there are many unharvested trees). Under investigation as a source o^ hydrocarbons.

Possible oilseed: oil content of kernels 41 %; sap. val., 190; iod. val., 71; fatty acid composition: linoleic, 22%; oleic, 38%; palmitic, 16%; stearic, 24%. High oil content could justify development for use as a source of lighting oil or to make soap.

Possible oilseed; seeds contain approximately: oil 31%, protein 24%. Egyptian plant material found to contain 1% rutin (a glycoside of quereetin and said to be of value in controlling certain haemorrhages).

Plant regarded as a noxious weed in Australia and Brazil. Fibre soon becomes waterlogged, does not stand rough usage, and has low tenacity. Lorn annual yield of fibre per plant and gathering of pods said to cause eye damage. Demand for the fibre fed in the 1950s and still indifferent though with the recently increased interest in kapok, which it resembles (but is inferior to), akund could follow suit perhaps.

Modern pharmacopeias tend to question ru tin's efficacy: see entry **no 208.**

Anon, 1964 Ayensu, 1979 Batanouny, 1979 Boehnnger Sohn, 1939 Chandler et *at.,* 1968 Croutefa/.j 1963 Crout *et a!.,* 1964 CSIR India, 1950 Drar, 1954

Erdmon and Erdman, 1981 Garg and Atal, 1963 Kirby, 1963

Maheshwari and Tandon, 1959 Meadly, 1971 Paroda, 1979 Rajagopalan *eta!.,* 1955 Santa Rosa, 1949 Santa Rosa, 1960 Siddiqui, I960 Somaliland Department at Agriculture, 1930 Teuvari, 1979 Uphof, 1968

Grindley, 1954

Sen Gupta and Chalcrabarty, 1964a

Ahmed ef *at-,* 1972 Hammouda er *at.,* 1975 Jones and Barclay. 1972

List of plants tolerant of arid or semi-arid - Part 17

f denotes a potential firewood source (see Introduction)

Current/past uses

Potential

Constraints

Citation data

Name(s)/Distribution

69. *Capparis spmota* L.

(Capers, abaar, kabar, lassaf)

India, Middle East, N. Africa, Europe, Australia.

70. *Carthamus oxyacs/itt>a* Bieb. (Poli, kantiari, wild safflower! Grows wild in NW. India and Pakistan, and extends westwards to the Caucasus.

71. *Carrhamus tine tonus* L.

(Saffiewer, false saffron)

Long been cultivated in China, 3E, Asian sub-con tinert. Middle East and N. Africa. Successfully introduced into the USA, Mexico, Australia, E. Africa, etc.

Pickled flower buds are commercial European capers used as a condiment. Bark used medicinally in the Middle East.

In areas where it occurs in abundance, oil is extracted from the seeds and used to make soap, in varnishes, etc. Thus, poli oil (obtained by cold expression) is used as a luminant, as food, in a hair oil, and for waterproofing. Roghum oil (obtained by dry hot process) is used in waxcloth, for greasing ropes and leather, for cementing glass, etc. Flowers used in indigenous Chinese medicine.

Originally grown as *a* dyestuff but is now utilised as a source Of a drying oil similar to linseed which Industrially is unequalled as a rapid even-drying, nonyellowing oil, suitable for the production of alkyd resins and in the manufacture of paints. Also widely used as an edible oil which is qf particular

value due to its high percentage of unsaturated fatty acids. Flowers sometimes used as a source of a natural red dye, carthamin, which is used in cosmetics, foodstuffs, etc.

Flower buds contain rutin (0,5%: *see* under *C. ovaTa* fof use), rutic acid, pentosans, a volatile substance with a garlic odour, and saponins. Seeds yield 34—36% pale yellow oil containing *a* high percentage of unsaturated fatty acids of the Cia series (e.g. oleic, linoleic). Bark also contains rutic acid and a volatile substance with a garlic odour. Possible source of cardioactive alkaloids. Extract said to combat liver damage.

Seed contains about *28%* oil, similar to safflower oil; sep. val.. 195; iod. val., 112.8; acetyl ual., 2.98; acid val., 1.34; unsap. matter, 0.42%. Fatty acids: myristic, 0.66%; palmitic, 3.1 %;stearic, 3,6%; oleic, 55.8%; linoleic 36.8%. Although generally treated as *a* noxious weed it has been suggested that the crop has possibilities as an oilseed for arid areas.

Seed contains about 26—37% oil, some improved types up to 48%; protein 12-22%; hulls 45-48%, thin-hulled types 14—13%. Characteristics of oil: acid val., 0.4-10; sap. val., 186-194; iod. val., 130-1 50. Wide diversity in fatty acid composition; average: linoleic, 63—80%; oleic, 10—20%; saturated acids, mostly palmitic and stearic, 6^t 2%, However, there are significant deviations and it is possible to produce, by breeding, oil with the proportions of oleic and linoleic reversed. Carthamin content of dried flowers, 0.3—0.6%, Considerable research on crop improvement has been carried out in the USA, Mexico and India.

A thorny and pernicious weed which is said to exhaust the soil.

Although the plant is drought resistant, it does require adequate moisture to thrive; namely approximately 300 mm p.a. rain (or its equivalent in irrigation). Has been grown successfully in the Negev desert, Subject to diseases and pests in many areas. Hand-harvesting difficult, but combine is successful in the USA.

Ahmed ef *af.,* 1972

Ayensu, 1979

Chopra *etsl.,* 1960

Evenari and Koller, 1956

Hammouda *et si.,* 1975

Seidemann, 1970

Sen Gupta and Chakrabarty, 1364a

CSIR India, 1950 Deshpande, 1952 Gardener, 1982 Maheshwari, 1963 Uphof, 1968

Beech, 1969

Claasen, 1950

Euenari *et at.,* 1971

Hodge, 1955

Knowles, 1955

Knowles, 1965

Knowles, 1967

Knowles, 1968

Knowles and Mutwakil, 1963

Setim, 1977

TP I, 1975

Williams, 1966

List of plants tolerant of arid or semi-arid - Part 18

72. *Caium butbocastanum* Koch (Black caraway, black zira, eBrthnut) Arid hills of W. Pakistan, Afghanistan and Kashmir,

73. *Cassia anguiti folia* Vahl;* syn. C *metficinalis* R'scii

(Tinnevelly or Indian senna)

Grows wild in E. Africa, Sudan, Arabian Peninsula and the Kutch region of India. Cultivated in the Tinnevelly district in southern India as a dry land, or semi irrigated, crap.

Seeds used as a carminative in indigenous medicine or as a spice. Starchy tubers eaten as a vegetable or in salads.

The fruit or leaves of the plant, often as an aqueous extract, are used as a purgative drufl Vvhich is widely used, particularly in the UK, the USA, and West Germany.

Has been suggested as a remunerative crop for the higher waste arid lands in Pakistan and India. Fruit Yields 2% essential oil, containing 18% aldehydes.

Fruit, or 'pods', and leaves contain 1.2—2.5% of sennosides A and 5, plus smaller quantities of allied compounds such as sennosides C and D (all being glycosides based or» the 2-substituted-4, 5-dihydroxyanthraquinones rhein and aloe-emodin, or the corresponding diartthrones}. A valuable drug in the treatment of habitual constipation. Yields in Tinnevelly 335—780 kg/ha leaves, 85—170 kg/ha pods. Considered tp be very drought resistant and to have potential for cultivation in India and Pakistan. Development of dry, granular extractions has stimulated demand for the crude drug.

The plant will survive on dry K 1 50 mm) summers but to thrive it requires cold lever snowy) winters and is usually only found at above 2,000 m 16,600 ft). Takes 4 years to flower from sowing seed (but then provides fresh growth from its tuber annually).

Adequate supply of cheap labour needed for handpickinQ and sorting, Sennoside content of plant varies during maturation and important to harvest at right Stage **for worthwhile yield — for pod, when immature; for leaf, when plant is flowering; also to dry at < 40°C to avoid degradation of the active constituents.**

Bhartiya, 1967 ChaudhH, 1953 CSIR India. 1950 Singh, 1973 Uphof, 1968

Anon, 1953b Chopra *et eL,* 1956 Chopra it *at.,* 1960 Fairbaim and Shrestha, 1967 Gupta. 1971 Gupta, 1974

Khorana and Sanghavi, 1964 Lemli and Cuveele. 1978 Pharmaceutical Society of Great Britain, 1973 Schmid and Angliker, 1965 Seaforth, 1962 Seluaraj and Chander, 1978

74. *Cassia italics* (Mill.) Lam. ex F. W. Andr.;

1960

Syn. *C, obovata* CoHad.,

C. obtusa **Roxb**

(Dog, Italian, Tripoli, Senegal or Jamaican senna I

Grows wild in Egypt- Sudan, S and C, Sahara down to Upper Senegal, Chad and Niger, through SW. Asia to India.

Utilized locally as a purgative drug; recognised in the French Pharmacopoeia.

1.1 — 3,8% anthraquinones (of the type described in entry no. 73) reported present in the leav&s, including rhein and aloe-emodin (*iee* entry no. 73! sennidins (non glycoside versions of the sennosidos) and a trace of chrysophanol (chemically related to rhein). Similar constituents present in the pods, although only traces of the anthraqui-none constituents. Considered as a cheap substitute for Alexandrian or Tinnevelty senna and sometimes used to adulterate these sennas.

Chopra efa/., 1960 Paris and Dillemsnn, Saber era/., 1962 Seaforth, 1962

Bender, 1963

Said to be a need for a critical study of the plant as a potential source of gum

75. *Cassia leptocarpa* Benth, SW. USA, Mexico, S. America.

Possible source of gum (and of sennosides? See entry no. 73))

Some authorities consider *C, angustifotia* to tie so similar to C, je«/ia as to be treated as the same species, but the trade continues to differentiate between them.

List of plants tolerant of arid or semi-arid - Part 19

76. *Cassia senna* L.:[H] *-y i *C. acLttifoiiv* Del

I Alexandrian sennal

See entry no 73.

Indigenous to thy Sudan, but found growing wild in other parts of Africa. CuItivated to a limited exlent in the Sudan, Egypt and I ndia

A purgative drug which is widely used, particularly in the USA, the UK and West Germany: see entry no 73.

Commercial pods contain 2.5-4.5% sennosides A and

B, plus a number of other anthraquinone glycosides based on rhein or aloe-emodin. Plant easy to grow. Development of dry granular extractions has stimulated demand for the crude drug: fee entry no. 73.

Anon, 1959b Chopra *et a!.,* 1960 **Crellin** *et at.,* 1961 Fairbairn *et at.,* 1958 Lemli and Cuveele, 1978 Paris and Dillemann, 1960 Pharmaceutical Society of Great Britain, 1973 Seafcrth, 1962 SelvaraJ and Chander, 1978

77. *Cassia siamea*

78 *Ceratonia tiliqua* L

(Locust bean, carob, St. John's bread)

Widely distributed in Turkey, Syria, and around the Mediterranean. Successfully introduced into S. Arnc'ica, California, Mexico, S.

Africa, Iricjia and Australia.

Endosperm of seed used as a source (yield 35% based on seeds taken) of gum (known as 'locust bean' or ’locust kernel gum' 'tragasol' or 'gum tragon[1]1 used by the food, confectionery, pharmaceutical, paper, textile, leather industries, etc. Whole pods used for food, animat feed, as a source o) sugars (especially 'cane sugar' — i.e. sucrose), alcohol and beverages, and as a substrate for citric acid production r also used medicinally and as a substitute for cocoa, coffee and chocolate, The wood is a source of natural dye used in textile manufacture in Argentina and is used to make carts and furniture.

The bean consists, by weight, of 5—20% seed, 80-95% pod Composition of both vary widely. Typical values for pod: carbohydrates, 50—70% (much of which usually present as sucrose and allied sugars) along with 'V 10% fibre, 5—8% protein, 2% fat, 10% moisture, 2-3% a&h.

Seed endosperm typically consists of ^80—85% of a galactose mannose (in ratio '"V[1] 1:5) polysaccharide (whence the gum) plus 3—4% pentosans, 6% protein, 3% fibre, 1 % ash, 5% moisture. Sugar content of pod (or of whole bean) similar to, sometimes exceeds, that of sugar cane or beet. Tannrn content Of ripe pods ""j 1.4%, mainly as gallic acid. Good demand for gum' a 2% aqueous soln. is semi-solid (1% in presence of borax). Process developed recently for production of fungal protein for animal feeding from waste pod shells, Successfully introduced into The Negev, where development of cultivars which shed their fruit on maturity is being investigated.

A drought-resistant evergreen but requires some irrigation if grown in areas with annual rainfall below about 300 mm. The gum is in competition with (but in some aspects superior to) guar, gum arabic, etc. Simple water extraction of the pod-sugars reported to be difficult: alcohol or similar solvent required. Meal from pods reported to depress growth of monogastric animals.

Aiumot and Nachiomi, 1962

Anon, 1962b

Anon, 1 974e

Anon, 1976a

Anon, 1979a

Binder et *ai„* 1959

Charalambous, 1966

Coit, 1951

Davies, 1970

Evenari et *a!.,* 1971

Griffiths, 1949

Imrie, 1973

Josy In *et at-,* 1968

Leo, 1950

Loo,1969

Macris, 1975

Mitrakos, 1968

Primo *et ai-*. 1964

Sekeri-Patarayas er *at.,* 1973

Singh, 1961

Storey, 1955

Uphof, 1968

"Some authorities consider *C. angusrifolia* to be so similar to *C. senna* as to be treated as the same species, but the trade continues to differentiate between them, [r] denotes a potential firewood source (see Introduction)

List of plants tolerant of arid or semi-arid - Part 20

Name<s)/Distribution

Cur rent/past uses

79. *Chamoecritta tepradenia* lGreenm.1 Cockered; syn. *Cassia Ivptadenia* Greenm.

Northern Sierra Madrearea of Mexico and adjacent USA,

30. *Chitopsis linearis* (Cav.) Sweet; syn. C. *saligoa* D, Don

{Desert willow)

SW USA.

81. *Chrozophora pticata* IVahl)

A. Juss. *ex* Spreng.

(Akasa; terba)

India; Africa (especially N. Sudan)

Wood used for fence posts, branches for making baskeTs; flowers, medicinally for coughs and as a stimulant in cardiac diseases.

Seed capsules source Of bluish-purple dye like litmus. Seeds and leave; used locally as a purgative.

Possible source of gym (and of serinosides? *see* entry no. 73)

Seed contains: 20—36% protein; 32—33% oii; sap. val,,

183; iod, vbl,, 142. Approximate fatty acid composition: saturated fatty acids, 5%; trans-IO-trans-12-octadeca-dienoic, 12%; trans-9-tram-l 2-oetadecadienoic, 16%:trans-9.trarS'11-cis-l3-octadecatrierioic, 25%; linoleic, 25%; undetermined, 18%. Investigated by American workers as a possible industrial oilseed in early 1960s. Flowers of possible interest — to perfumery trade.

Barker *eral.,* 1950 CSIR India, 1960 Uphof, 1968

Seeds contain 39% of an oil (which resembles cottonseed oil), lod. val,, 112; sap. equiv., 294; f,f *s,* (as oleic), 2.2%; unsap. mat ter, 0.9%. Fany acid composition: linoleic, 52%; oleic, 25%; palmitoleic, ^0.2%; stearic, 13%; palmitic, 9%; arachidic, 0.6%; myristic, 0.2%, Possible oilseed suitable for soapmaking.

Said to be a need for a critical Bender, 1963 study of the plant as a potential source Of **gum.**

Benson gnd DarrOw, 1944 Chisholm and Hopkins, 1963 Earle *eta!.,* 1960b Hopkins and Chisholm, 1962 Jones and Barclay, 1972 Maurer, 1964 Uphof, 196S

At present only grows Wild and doubtful if available in commercially exploitable quantities. Plant also contains a poisonous principle which could handicap harvesting. Seeds very small and so collection may be difficult,

82. *Chrysarsthemoides monilt'fera* (L.} T. Norl; syn. *Osteosperrrum monitiienim* L.

Southern Africa

Seeds contain 49% oil **with** iod. val. **146 and containing. Only grows wild,** by **u.v., 38% conjugated triene and 2% conjugated diene (dimorphecolic?) acids. Investigated in** early **1960s as a** possible industrial Oilseed.

Earle *et a!,,* 1964 Jones and Barclay, 1972

List of plants tolerant of arid or semi-arid - Part 21

Current/past uses

Constraints

Citation data

83. *Cixrullus coiocyrtthh* IL.) Schrad.

(Colocynth, bitter apple)

Drier parts of Africa, Mediterranean, Turkey, SE. Asian sub-continent.

***[Cnidoscalus* spp. - see under syn, *Jatropha* spp.]**

94. *Coichicum rixchii* R. Br. Middle East.

Commercial source of the drug 'colocynth', being the dried unripe fruit pulp; a powerful! purgative. Seeds contain brownish-yellow, bitter oil. Roots used in traditional medicine, as a purgative. OiJ is used to make soap.

Fruits consist of 70% puipy mesocarp, 5% seeds. Juice reported to contain an anticoagulant. Glycoside content of fruits: 0,22%: Of-elaterir 2-D-glucopyranoside and its aglycone fcucurbitacin E*) have been detected in all parts of the plant; curcurbitacins B, i and L (both free and glycosidal forms) in stems, leaves and fruits, highest in fruits. Seeds yield 16—20% oil, characteristics and com-poiition of which vary according to environment. Indian oil; sap, val., 297.4; iod, val., 124.6; unsap. matter, 1 .6%. Fatty acid composition: linoleic, 592%; finolenic, 1.6%; oleic, 21.1%; arachidic, 1.9%; stearic, 6.6%; palmitic, 9.6%, Algerian oil: linoleic, 65%;oleic, 17.2%; hexsdecenoic, 1.2%; tetradecenoic, 03%; stearic, 5.6% palmitic, 8.9%; myristic, 1,2%. Seeds source of protein. Anti-cancer activity of Q-e later in investigated in late 1950s. Possibility of developing the plant as a source of semi-drying linoleic-rich oil suggested. Yield df seed estimated to be about 6,700 kg/ha. Ripe fruit pulp possible source of p«ctin. Plant is useful as a sand binder and is very drought resistant.

Potential source of the drug colchicine (used in particular to counter gout), Flowers contain six times as much colchicine as bulbs. Colchicine content of Israeli bulbs reported to be satisfactory, that of Egyptian to be very low. Possibility of breeding improved high-yielding strains and growing in beds to facilitate harvesting has been suggested.

Only a limited demand for colocynth nowadays: has been mainly superseded by less drastic and less toxic purgatives; and a-elaterin has not apparently fulfilled its earlier promise (absent from Very variable'. Oil is inedible due to its purgative action and bitterness'*'.

Abu-Nasr and Potts, 1953 Boyko, 1954

Chawan and Sen in Davis, 1978c Darwish-Sayed *et* a/., 1973 Darwish-Sayed *etal.,* 1974 Drar, 1954

El Khadem and Abdel Rahman, 1962

Evenaria and Koller, 1956 Faust *et at.,* 1958 Gitter *ez at.,* 1961 Lavieeta/,, 1964 Martindale, 1977 Misraera/., 1962 Paroda in Davis, 1978c Pillai eta/., 1957 Sen and Bansal, 1979 Sen Gupta and Cbakrabarty, 1964b Tewari. 1979 Zaitschek, 1953

Boyko, 1954 Drar, 1&54 Martindale, 1977 Zaitschek, 1953

Quick-growing tree used for firewood, boat and house building; is grown in dry river

beds.

Suitable for making charcoal. Not affected by soil salinity. Reaches height of 60-60 ft f15~18 m) in 10-12 years, giving long straight poles. Wood is light but hard-grained.

Seeds murt not be covered and must be watered copiously for 4—5 months.

Howes, 1951

85. *Cotophospermum mopane*[f]

86, *Conoccarpus lancifolius* Engl.

(Damas, hodeti)

Somalia; introduced into Kenya,

Sudan, N, Yemen, S. Yemen.

t ^wr^{U};^{bita}»^{Ci}"ITK^{e} ^{hi9},^{hIV} ∘∗V9en∘∗ed molHCules h^{35}∗$^{1\ the}$ triterpenoid skeleton, usually C30 or C32 with 7-9 oxygen atom, and isolated from various Cucurbitaceae

isftfuifus **(Thunb.) Mansf., also an AZ plant, contains in contrast an *edib/e* oil (Paroda, 1979).**

denotes potential firewood source bee Introduction!

List of plants tolerant of arid or semi-arid - Part 22

Nameftl/Distribution

Current/past usw

87, *Copernicia australis* Becc. (Caranday)

Native of NE. 6ra;it end Chaco side of Rio Paraguay in Paraguay-

88. *Copernicia cerifera* (Arr.Cam.) Man.

(Carnaubal Native of NE. Brazil.

Timber utilized locally for construction; leaf straw for hats; fibre for ropes, etc.

Source of hard high-quality wax, used in floor and other polishes, carbon paper, leather finishing, inks, gramophone records, lubricants, cosmetics, etc. Also used locally as a source of fibre. Pulp of fruit ground into flour for local use. Nuts used as a source of oil.

Potential source of hard wax. Thus the 1 saves yield about 4 g each of clean wan, similar to qamauba tsee entry no. SSI; mf, 82°C; acid val., 2.7; sap. val., 643; iod. val 10.5; unsaps54%. Elementary fibres 1.5—3.5 mm long; IO-4Q^rrrt thick. Wood yields 35% cellulose. Possible source of paper pulp. Fruit yields (55%l a non-drying oil.

Leaves yield about 5—15 g of max each (yield increases with droughtl. M.p., 85"C; acid val., 4; iod. val,, 10.1 — 13.5; sap. val., 78-80; hydrocarbons, 03—1%; long-chain aliphatic esters, 38-40%; monohydric alcohols, 10—12%; (j-hydroxy-aliphatic esters, 12—14%; p-methoxycinnamic aliphatic dl*sters, 5—7%; p-hydroxycinnamic aliphatic diesters, 20—30%; an jncombmed triterpene 6iol,0,4%; uncombined acids, etc., 5—7%, R and D in Braril has led to increased yield Of wax and a whiter product with increased oil retention. Possible new use of the improved product is as *a* time release agent for insecticides, fungicides and fertilizers. Current developments include the possible use of leaf fibre for paper making and of waste pulp for livestock food.

Possibilities of exploiting wild palms as a source of hard wax was considered in 1940—1950s but handicapped by *a* shortage of labour for harvesting and processing and also (for floor polishes) by increasing competition from synthetic materials. Also competes to some degree with carnauba wax and candelilla was *i^es* entry nos. 88 and 1271. A semi-arid rather than arid plant.

Wax is obtained from wild palms. Suffered severe competition in late 1950s until early 1970s from polymer-based floor polishes, etc, but shortage of styrene monomer led to increased demand in 1970s. However, worldwide there is currently (1979) an over-production of carriauba with Stockpiling occurring in ejg. Brazil. Attempts to develop cultivation in other areas have met with little success. Possibility of decrease in supplies as land is cleared in Brazil to grow other crops such as maize, castor and cashew.

Anon, 1954a Bertuzzi ef *sf.*, 1939 Markley, 1955 Medeiros Tranooso, 1945 Medeiros Trancoso, 1948

Anon, 1953 Anon. 1954b Anon, 1973b Anon, 1976b Barnes eta/., 1965 Santa Rosa, 1970 Sweet, 1973 Taube, 1952

Vandenberg and Wilder, 1970 Vollmuth and Baldini, 1973 Walters etaJ., 1979

List of plants tolerant of arid or semi-arid - Part 23

Current/past uses

Potential

Constraints

Citation date

Name ^/Distribution

39- *Cordeauxla edutis* Hemsl.

(Yeheb, yebb, jeheb, geeb, geheb)

Somalia and S. Ethiopia. Introduced into Tanzania and Kenya.

90, *Crambe abyssinica* Hoehst. ex. R.E. Fries

(Crambe; Abyssinian-kale, -cabbage or -mustard)

Found growing wild in the Ethiopian foothills and N. African plains. Successfully introduced into a number of countries including the USA, USSR, Canada, Kenya, Venezuela and N. Nigeria,

A leguminous desert shrub whose fruit pods yield edible seeds, which form the staple diet of the region's nomads, and a magenta pigment used locally to dye textiles. The leaves are used as a tea substitute.

Gives an oil (simifar to rapeseed oil) used for soap, In margarine, and in manufacture of lubricants, Good natural source of erucic acid which on ozonolysis yields brassylic (HOOC (CH_a)|, COOH] and pelargonicacids (CH_3 (CH_2)$_7$COOH) used variously in the manufacture of polyesters, alkyd resins, plasticizers, synthetic fibres, rubber additives, etc. In the USA, residual meal is used for animal feed after removal of thioglucosides by e.g. treatment with ammonia and is considered to be one of their most promising new industrial crops with much recent R and D activity.

The seeds contain 24% sugars, 37% of ottier carbohydrate, 13% protein, 11% fat, 3% ash and 9% moisture. Another analysis confirms the high carbohydrate, low protein and low fat contents. The seeds are considered to have high nutritive value, are low in anti-nutritional factors but also low in methionine. The oil is intermediate in type between liquid oils and solid fats, tastes less pleasant than olive oil but could be used for soaps; the meal could be used for extraction of sugars and the residue for fodder or manure. Nuts 3 possible coffee substitute. Fruits ripen completely within 5—6 days. The chemistry of the dye, a quinone, has been examined and its chemical structure deduced.

Hull comprises 25%, or more, of seed weight. Crude protein content of dehulled seed 22-37%; oil content 3654%. Oil has sap, val$_v$ 169; iod, vaL, 94; f.f*a*, 0.4%; unsap. matter, OB—1 .□%. Fatty acid composition: erueic, 58-61%,oleic, 20-21%; linoleic, 6-9%; inolemc, 3—6%; palmitic, 2—3%; eicosenoic, 3—4%; behemc, 1 — 1.5%: stearic, hexadecenoic, and docosadienoic, all < 1K. Possibility of using the oil to produce, by hydrogenation, a wax with proparties similar to those of sperm whele oil is currently being investigated in the USA. Residual meal contains 46-58% crude protein but afso 8"10% thioglucosides (principally epiprogoitrin, a growth inhibitor), and a bitter-tasting alkaloid, sinapine (0,46%), Suggested cool-season crop -for India.

Attempts to grow OLItside natural habitat have not succeeded, flequires rain for normal fruiting. Plant is never found in pure stands. Pressure from overgrazing (by goats and camels) and from heavy use by nomads said to be threatening the plant with extinction. Seedlings grow only slowly, at least until the extensive and deep root system has been established.

Relatively drought resistant but requires moisture during flower and seed development, Requires relatively cool growing conditions (1 5— 20$^{t>}$C). In semi-arid areas seed yields increased by irrigation; average 2,000 kg/ha in cooi semi-arid regions. Traditional oilseed processing methods have proved

expensive in the USA — need tor further research; also on new methods of treating the meal to remove the thiogluoosides and to improve payability for animal f&eding *{see* left): maximum utilization of the meal is essential for economic processing.

BrilII and Mulas. 1939 Fabriani, 1940 Fehlmann and Niggli, 1965 Greenway, 1941 Lister *et at.,* 1955 Miege and Milge, 1978 Triaand Fabriani, 1940 Uphof, 1968

Anon, 1966b Anon, 1974c Asthana, 1972 Austin and Wolff, 1968 Baker *et at.,* 1975 Chang *et at.,* 1975 Cornelius and Simmons, 1969 Duisberg and Hay. 1971 Earle era/., 1965 Godin and Spensley, 1971 Kirk *et at.,* 1966, 1971 M us takas eta/,, 1965b, 1968,

1976

Nieschlag eta/., 1977 Princen, 1982 Spencer ef $_{a}f$ 1974

List of plants tolerant of arid or semi-arid - Part 24

Nanr>e (s) / D is tr i b ut ion

Potential

Current/past uses

91. *Crocus satlvus* L.

(Saffron)

Originated in eastern Mediterranean, Turkey. Iran. No* spread to N. of SE. Asian sub-continent, Spain, China, etc.

92. *Cryptostegte grandiftora* (Roxb.) R. Br.

(Madagascar rubber vine)

Indigenous to India, but "found wild in arid and semi-arid areas of EE. Asian sub-continent. Introduced into Mexico, SW. USA arid Australia.

93, *Cucumis prophetarum* L.

{Wild cucumber, Mandera cucumber) Arid parts pf Africa, Arabian Peninsula, SE. Asian sub-continent.

Flower stigmas source of yellow dyes tuff and food flavouring. Used in indigenous Indian medicine.

Source of a natural rubber.

Fruit pulp used as s purgative and emetic in indigenous medicine.

Typical composition of commercial saffron; moisture, 15,6%; protein, 12 4%; starcti and sugars, 13.4%; other N-free extractives (carbohydrate), 43,6%, crude fibre, 4.5%; ash, 4 3%; essential oil, 0.6%; 'fixed[1] (fattyl oil,

5,6%. Chief pigment a yellowi(h-f«J carotenoid-glycoside, crocin; other carotenolds present include lycopene, *Or* carotene,jj-carotene, zsaxanthin and crocetin. One part saffron will colour 100,000 pans water. Yield in India of dried flower stigmas 2.5 3.0 kg/ha. The corms of the plant regenerate for 10 years or so before needing to be renewed.

Latex content varies with season, soil, age Of plant and tissue; normally highest in the leaves: average 4%. improved hybrids 8J6%. Solids in latex: rubber, 57.196; resins associated with rubber, 7.2%. Rubber comparable in quality to that of *Hevea.* Seeds contain 10.8% semidrying oil, 4.7% rubber and 17,5% resin. Crop considered to have potential in arid areas of India as an oilseed, source of fibre and anti-eroiion crop. Fivecardenolides, some of which showed anti-tumour activity and including a new natural product (16-propionylgitoxigenin), recently detected in plant extract.

Seeds constitute 5-2% by weight of fruit: Oil content, 28.4%; sap. vat,, 106.8; iod. val., 133.0; acid val., 11.6; unsap. matter, 1.4%; saturated f«ttv acids, 10jS%. Protein content of meal after oil extraction, 25.6%. Cucurbitacins

B, C, D and Q1 Uee footnote* to entry no. 83) isolated from fruits and also a sterol, pro-phenerosterol. Has been suggested as a potential oilseed for arid lands.

Very drought resistant in the dormant stage, but yield benefits from moisture prior to flowering in autumn, Studies have not revealed any constituents of therapeutic value. High value crop but requires supply of cheap seasonal labour for harvesting, which is very labour-intensive. Product often adulterated.

Investigated thoroughly during World War 11 as a source of natural rubber, but yield too low and cost of collection too high for it to compete successfully with *Hevea* rubber.

A bitter resinous substance, myriocarpin, which produces nausea and is toxic to animals, is also reported present in the fruit pulp.

□hingra *at al.,* 1975 Ingram, 1969 Mad an *et a!,,* 1966

Anon, 1944a Buchanan eraA, 1978a Cruse, 1949 CSIR India, 1950 Doskotch *et al,,* 1972 Polhamus *et si.,* 1934 Pol ham us, 1962 Siddiqi and Mathur, 1946 Stewart *et a!.,* 1948

Aslam *et bI.,* 1965 Boyko, 1954 CSIR India, 1950 Khan and Zehra. 1975

List of plants tolerant of arid or semi-arid - Part 25

Current/past uses

Potential

Constraints

Citation date

Name (s)/Distribution

94, *Cucurbits d/gitata A* Gray USA — Arizona, Mew/ Mexico, Texas.

95. *Cucurbits foetidissima* Kunth

(Buffalo gourd, chilicote, mock orange)

SW. USA, Mexico: much more widespread than *C. digitata* and *C. pa/mata.*

Seed used as a foodstuff bv the American Indians,

For many years, American Indians have used tl>e seeds for food and the fruit pulp and vine as soap substitutes. The vine winter die-hack has been used as fodder,

Seeds contain about 21% protein and 27% of a drying oil which is similar to linseed oil: iod. val., 139.2; fatty acid composition: palmitic, 10%; stearic, 5%; oleic, 24%; linoleic, 43%; conjugated triene I? punicic) acid, 18%. Seeds rich in phytin (a sugar phosphate). Roots contain about 49% starch; iodine affinity value* 4,42;diameter of starch grains 3—1 7/im, average 9;jm; gelatinisation temperature 65,S—6QJ3[J]C. Yields of seed from uvjJd plants have been estimated at 550-3,300 kg/ha (from very limited observations). Has been suggested as a potential oilseed (? and starch source) for desert areas: it is a perennial which thrives in hot arid conditions.

Fruit — 44% seeds, 56% pulp;crude protein content of pulp, 30.1%; fibre, 27,7%; ash, 14.2%. Seed: moisture,

A3%: crude protein, 31.*3%;* crude fibre, 25.6%; oil,

30.4% (which has iod, val. 133.6 and fatty-acid composition: palmitic, 11%; stearic, 1%; oleic, 50%; linoleic, 38%; but negligible triere -in contrast to entries nos. 94 and 96), Seed consists of 30% hull, 64% embryo. Embryo: moisture, 4.S%; crude protein, 37.5%; fibre, 63%; ash, 4.2%;oil, 48% (which has - sap. val., 191,8; iod. val.,

136.1; unsap, matter, 1.53%; (.fa. (as oleic), 20%. Fatty acid composition: linoleic, 61 J0%; oleic, 23.1%; palmitic, 9.3%; stearic, 4.2%; linolenic, 1.5%; myristic 0.2%). Seed rich in phytin I .tee above). Fresh roots: moisture,

67—69%; starch, 15-1 7%; granules similar to those of cassava starch, iodine affinity value* 4.07; diameter 2-17fim, average 5^m; gelatinisation temperature 57.0-80.5°C. All parts of the plant, except seeds, contain cucurbitacins (bitter triterpenoid glycosides[1,]}. Alcoholic extract of root has oxytocic action (aids childbirth), Potential value as an arid zone crop recognised for past 30 years, both as an oilseed (protein and oil from seeds) and root crop (huge tubers as source of industrial starch).

Currently research is being carried on in Arizona, Mexico, Lebanon, India and Iran: need for increased input on breeding, cultural practices, etc. Potential seed yield estimated at 3,000 kg/ha, break-even point in the USA estimated at

2,000 kg/ha. Need to dehull seed; high fibre content restricts use of hulls, or whole seed meal, for animal feed.

The seed oil is difficult to bleach and this could restrict its use. The effect may be due to weathering of fruit before harvesting, and drying under shelter might improve colour. Protein is low in sulphur-containing amino acids and lysine, The starch has to be extracted with brine to avoid bitters.

Bemis *eta!.,* 1967a Berry et a/., 1975 Bolley *et a!.,* 1950 Cruse, 1949 Curtrs. 1946 Duisberg, 1952b Krochmal *eta!,,* 1954 Jacks *st at.,* 1972

Bemisera/,, 1967a, 1975, T978 a, b, 1979 a, b Berry *eta!.,* 1975, 1976, 1978b Bolley *eta/.,* 1950 Brooks in Davis, 1978b Curtis, 1946 Duisberg, 1952a, 1952b Ferguson, 1955 Jacks eta/., 1972 National Academy of Sciences

1975 Shahani *eta!.,* 1951 Smith ef *at.,* 1959 Uphof, 1968

' For significance, iee entry no. 36. ˚ cf, footnote* to entry no. 83.

List of plants tolerant of arid or semi-arid - Part 26

Name(s)/Distribution

Potential

Current /past uses

96. *Cucurbits patmata* S. Watson (Covote meloni USA — California.

97. *Cyamopsis tetragonoloba* (L.) Taub.

(Guar, cluster bsanl Probably originated in Indian subcontinent but now widely distributed in tropics and sub tropics.

98. *Cymbopogon cotorarus* (Nees) Stapf; *syn.Artdropogon coloratus* Nees

(Pillu grassl

India — Tinnevelly district as far as the Anamalai hills, and in Kgrnatik (Madras).

A legume whose seeds are a source of gum used in the food , paper, textile and pharmaceutical Industries, and as a flccculant and filterant in the refining of mineral ores, etc. Residue left after extraction of gum utilised as an animal fodder. (Seed themselves sometimes so used but this represents a waste of the eumh Seeds used for preparation of protein-enriched foods, and immature seed pods eaten as a vegetable. Used as appetite depressant, to help treat diabetes, and in cosmetics.

Highly aromatic, xerophytic plant which yields an essential oil used locally [f]or perfuming soaps.

Seed contains about 24% protein end 27% of a drying oil with, like entry no. 94, some similarities to linseed oil: iod. val.. 139.2; unsap, matter, 1 -6%: average fatty acid composition: palmitic, 8%; stearic, 4%; oleic, 25%; tinoleic, 40%; linolenic, 6%; conjugd. triene (? punicic) BCid, 1 7%.

A potential AZ oilseed (and *?* source of starch from tubers).

Seed consist of: hull, 14-16%; endosperm, 38-46%, cotyledons. 40-46%. Endosperm contains 68-70% of a polysaccharide,galactomannan gum (commercial suer), with approximate composition: moisture, 12%: protein, 5%; gum, 80%: fibre, 1.454; fat 0.7%; ath 0.9%. It is composed D-gaJactopyranose and D-mannopyranose units, has high viscosity at low concentrations and car function over a wide pH range. Demand for guar gum has shown a considerable increase in recent years. India and Pakistan main producers (the former exports 'V 40,000 tonnes, value S20m, p.a.f; USA principal import market, although crop is being developed in SW. USA. Possible new use for guar is in diabetic diets. Thought that yield oould be improved by genetic improvement and by batter field management.

Yield of oil, obtained by steam distillation. 0.35%,sp, gr. (at 15°C),0.91 1-0.920; optical rotation, - 7“ 43'to -10° 42'. Composition (old data): geraniol (partly as the acetate) variously put et 15-33%; terpene aldehydes (mainly ditronellal), 34-50%; and hydrocarbons (? mainly limonene), 7%.

Rather restricted in distribution compared with *C. digitate* end C. *foetidissima.*

Can be grown successfully in arid areas but needs a little supplementary irrigation. Con^petes with locust bean gum, gum arabic and tragacanth (see entry nos, 78, 3 and 52).

The oil resembles lemongrass oil but is considered to be 'inferior' to it.

Bemisera/., 1967a Bolley et *a!.,* 1960 Cruse, 1949 Curtis, 1946 Duisberg, 1952a Krochmal era/., 1954 Jacks *at at.,* 1972

Anon, 1974b, d

Anon, 1979a

Bhatti and Sia , 1971

Hymowitz and Matlock, 1963

Kay.1979

Paroda, 1979

Poats, 1960

Uphof, 1968

Whistler, 1932

Whistler and Hymowitz, 1979

Choudhury, 1961 CSIR India. 1950

List of plants tolerant of arid or semi-arid - Part 27

Citation data

Potential

Constraints

99. *Cymbopogort jwafartajsa* **(Jones) Schult; svn.** ***Andropogon iwafa/ictisa*** **Jones**

I Khavi grass)

5E- Asian sub-continent; especially abundant ir> the desert areas of the Punjab.

100. *Cymbopogon martini!* **(Roxb.) Stapf var, man's*; syn.** *Andropogon martmit* **Roxb, var,** ***motia.***

(Palmarosa grass, rusa grass)

India, especially the central/ southern areas such as the Deccan plateau, Also Brazil, Paraguay, Angola, Indonesia.

101. *Cymbopogon praximus* (Hochst. ex A, Rich.) Stapf; syn.

C. *schoenamhus* **(L.) Sprang, subsp.** *proximus* **(Hochst. ex A. Rich.)**

Ma ire & Wei ler, *Andropogon* ***proximus*** **Hochst. ex A. Rich, (Mahareb, halfa bar)**

Upper Egypt, Sudan, Ethiopia,

N- Nigeria, Ghana and Guinea.

As source of an essential oil suitable for perfuming soaps. Used as cattle fodder in times of drought.

A perennial grass which on steam distillation yields the 'palmarosa oil' of commerce, traditionally produced from wild stands in India for export (95 tonnes p,a. late 1960s) to USA and Europe for use in perfumery (gives rose-like odour, e.g. to quality soaps) or as a source of geraniol.

The air-dried leaves and stems are highly valued in indigenous medicine in Egypt and Sudan as an antispasmodic drug (the amispasmodic principle is now known to be a saturated dicyclic sesqui terpenoid diol, proKimadiol, CisHzaOa).

Yield of oil, by steam distillation, 0.4-1.0%; sp. gr. (at 15° C), 0.920; acid no., 5.6; ester no., 21,0; ester no. after acetylation, 117.8; total alcohols, 34,0%. The oil, which has been suggested as a possible substitute for palmarosa oil (next entry), is reported to contain up to 24% *d*-**A^4-carene, and up to 80% piperitone (readily convertible into thymol, a mild antiseptic). Also reported present, an alcohol with rose-like odour and a sesquiterpene alcohol with b.p.at 31 mm Hg vacuum of 176-177° C, Roots contain 0.4^0.9% volatile oils; also resins and hitter principles.**

Top two-thirds or so of the plant cut for use (regenerates for several years) and after brief drying yields up to 1% oil, dry basis, provided care is taken with the distillation, Sp. gr., 0.874—0,889; ester value 'V 35; main cohsituent l'V90%) is geraniol, partly as acetate/caproate. Most of the oil is in the leaves. The plant size and the oil yield per plant vary widely in natural stands, and also to some extent in 7-ray produced mutants — so giving the possibility of commercial development of higher-yielding strains.

Considered to hsve potential as an essential-oii crop, the oil being suitable for the perfumery trade and as a raw material for preparation of menthol. Yield and composition of oil varies widely according to habitat and maturity. Yield of up to 6.8%, fresh wt. basis, claimed for leaves gathered immediately after flowering (optimum) Main components: piperitone Uee entry no, 99),

22—88%; elemol, 0.4—39%; and ^-eudesemol (both sesquiterpenes), *2—20%.* Pipertone content reported to increase with aridity.

Carene is a skin irritant end this could restrict the usefui-ness of the essential oil in perfumery. Wide variation in 0if composition.

Plant needs light weJI-drained soil and although said to survive hot, fairly dry climates, some claim that 805 mm rain p,a., or equivalent irrigation, is desirable for good yield. In the wild, the plant grows in scattered patches and collection/distillation tend to be *ad hoc/*rudimentary. More recently grown in plantations (especially Indonesia),

Unusually wide variability in oil yield and composition could be 3 disadvantage for large-scale exploitation.

Bradu *er 3!.,* 1977 Choudhury, 1961 CSIR India, 1950 Guenther, 1950 Hussain and Hassan, 1958

Anon, 1972 Choudhury, 1961 CStR India, 1950 Dutta and Sahoo, 1977 Guenther, 1950 Gupta, 1969 Gupta, 1972 Paroda, 1979 Virmani *et at.,* 1967

Abdel-Moneim *et* a/., 1969 Banthorpe era/., 1976 Drar, 1954 Guenther, 1950 Radwan, 1975 Rovesti, 1971

C. marttnu **(syn.** *A. martini)***) var.** *scfia* **requires a mouter, and shady, habitat and yields an oil, gingergrass oil, with commercially less desirable characteristics than palmarosa oil.**

List of plants tolerant of arid or semi-arid - Part 28

Name(s)/Distribution

Potential

Current/past uses

102. *Cymbopogon scfroenarithtts* (1_.) Spreng. subsp *scboensnthus* syn. *Andropogon schoenanthus* L.

ICamel grass)

Widely distributed in arid areas of N. Africa, Arabian Peninsula, Iran and SE. Asian sub-continent,

103. *Dssylirion wheeteri* S. Wats, ex Rothr.

(So to I)

USA ISonora desert and Texas), Mexico

104. *Datura inoxia* Mill.* ; syn.

***D. msreloides* DC. ex Dunal (Black datura)**

Native of Mexico, but now widespread especially in SE. Asian sub-continent and Egyptian deserts.

106. *Datura motet* L,

{White datura, thorn apple*') Native of tropical Asia and possibly Africa; now widely distributed in drier parts of the tropics arid sub-tropics.

Used locally as a perfume and diuretic.

As source of alcohol (e.g, was so utilised in Texas during World War II).

Source of the alkaloid hyoscine (scopolamine) used in surgery and childbirth and to prevent travel sickness, etc. Commercial supplies of the drug consist of dried leaves and flowers; hyoscine content, 0.25—0.55%.

Source of the alkaloid hyoscine (scopolamine; *see* previous entry), the dried leeves and flower heads being the normal commercial form (hyoscine content should be 0.25—0.55%); also used in traditional medicine. Plant is understood to be grown commercially in Spain and Egypt.

The dried gass yields about 1% of oil on steam distillation; sp.gr. fat 15°C), 0.905. Reported to contain 3-10% phenols, 10—30% aldehydes and some phellandrene (hence the elemioil-like odour I. A typical desert plant; has been suggested as being worthy of further investigation.

Seeds yield 26% protein and 22% oil (which has iod. val,, 146; sap val., 182; and fatty acid composition: Cis nonconjugated disne |e.g. linoleic 1. 73%; monoene (e.g.oleic), 14%; saturated, 8%). Possible source of a 'fixed' (fattyl oil, fairly high in unsaturated acids. Fibre suitable for cordage.

Alkaloid content varies according to season and location, normally highest in seeds (upto 0.45%). Seeds also contain 14% protein and 19,6% 'fixed' (fatty) oil.

Thrives on wastelands and has been suggested as a possible drug plant for cultivation on wastelands in India. Pakistan and Egypt,

Alkaloid content varies according to location, season and part of plant. Seeds contain T3 —14% protein and 16—19% oil (which has iod. val.$_r$ 104-119; sap. val., 179-1 38;and fatty acid composition; linoleic, 52%; oleic, 32%; palmitic, 13%; stearic, 3%). Very similar to *D. irtpxia* Use entry no. 104), Has been suggested as a possible crop for the Negev desert and SE. Asian sub-continent.

Limited demand only in international trade (but *see* entry no. 105),

Hyoscine can now be obtained synthetically.

All parts of the plant are narcotic (? harvesting problems).

Similar problems apply as to entry no. 104, which see. Considerable variation in hyoscine content reported in Indian samples.

Guenther, 1950

Paris and Dillemann. i960

Anon, 1945 Earle *et at.,* 1960b Gentry, 1972

Arnon, 1972 Chopra eta/., I960 Drar, 1954

International Trade Centre, 1974 Jonas and Earle, 1966

BurkhiJI. 1935 Earle *et at.,* 1960b Earle *et at.,* 1962 Evenari ef *at.,* 1971 Grindley, 1954

International Trade Centre, 1974 Karnick and Saxena. 1970 a, b Martindale, 1977 Shah and Khanna, 1963 Shah and Kfianna, 1964 Shah and Khanna, 1965

*** Sometimes referred to in the literature as *D. metsl* var. *fastt/osa.* $^+$ Used for both £)_ *mstpt* and *D. stramonium.***

List of plants tolerant of arid or semi-arid - Part 29

Citation data

Potential

Constraints

106. *Datura stramonium* L. (Devil's apple. Jamestown weed, stramonium, thorn apple[+])

Thought to have originated around the Caspian Sea; now found in a wide range et habitats in Europe, Airies America and Asia.

Source of the drug stramonium, Similar to belladonna, and used as a narcotic and anti'Spasmodic; widely used to treat asthma. Commercial form of the drug consists of the dried leaves and flower heads; alkaloid content should be 0.25—0,5%, and consists mainly of hyoscyamine {C17H23O3N; nrp„10S C). Also used as a source of the alkaloid atropine.

Seeds contain 0,1-0.3% alkaloids; also 18% protein, 1627% oil (with sap. val189.5: iod. val., 130.5; fatty acid composition; linoleic, 61%; oleic, 23.5%; palmitic,

11.5%; stearic, *4*%). Suggested as a possible crop for Egyptian deserts. Attempts have been made to develop the crop in India and Pakistan. Experimentally, yields in India average 1,100-1,700 kg/ha of leaves and 770 kg/ha seed. Use of nitrogenous fertilisers favours alkaloid formation. Stramonium is listed in many pharmacopoeias.

Attempts to grow stramonium in USA during World War [| were not very successful, because of harvesting difficulties. May need nitrogen input for acceptable alkaloid yield: see left. Must be used carefully — toxic side effects. Competition from synthetic anti-spasmodies.

Chopra ef a/., 1956 Chopra *et at.,* 1960 Crooks, 1949 Drar, 1954 Grindley, 1954 Jones and Earle, 1966 Khan and Hussain. 1960 Martindale, 1977 Wahid and Kazmi, 1960

iDaucus visnaga L. - synonym for *Amrni vrsnjga,* which see)

107. *D/morphotbecs cuncata* DC, Native of S. Africa.

Seeds contain (hull-free basis) 38—41 % protein, 32% oil -which has iod. val.ᵣ 1 37: conjugated acids in oil: diene Idimorphecolic acid), 69%; triene, 3%, Dimorphecolic acid (9-hydroxy -10, 12-rrani-rranj-octadecadienoic acid) contains multiple reactive groupings, similar to The ricifi-oleic acid in castor oil. Hence a possible industrial oilseed and source of dimoiphecolic acid (used in the manufacture of plastics, paints, lubricants, surfactants, etc.], The oil is reported to be similar to tung oil and produces comparable phenolic resins. Thus with other members of the genus *DiffiOrphotbeca, D. cuneata* has been investigated as a possible oi Iseed in the USA. Found to be a drought-resistant shrub, which is fairly resistant to frost, and 90% of its seeds mature over 20 days (so mechanical harvesting is feasible), its seeds do not shatter as easily as those of *D srrrauta* Use next entry). Estimated average yield 1,700 kg/ha.

In the USA found to be susceptible to disease (but despite this considered a promising cropj.

Barclay and Earle, 1965 Duisberg and Hay, 1971 Earle *et a!,,* 1964 Jones and Barclay, 1972 Rheineck and Sobol, 1963 Witling ha rr> and White, 1973

List of plants tolerant of arid or semi-arid - Part 30

t Used for both *P. mete!* and *D, stramonium*

Name(s)/Distribution

Potential

Current/past uses

108. *Dirnorphotheca sinuata* DC; syn.

***D. auranlhiaca* DC.**

(Cape marigold)

Native of S. Africa; but now found widely in The USA too.

Widely used in the USA as an ornamental.

Seeds contain (hull-free basis) 34-38% protein; 28-30% oil (with sap. vaL, 1 77; iod. val., 124; fatty acid composition: dimorphecolic, 66%; linoleic, 14%: olaic, 10% palmitic, 4—5%; stearic, 4—5%: miscellaneous acids, f»%), Potential source of a drying oil similar to tung oil, and a source of dimorphecolic acid: *see* previous entry. It is the most extensively researched of the *Dimorphotheca* spp. Adapted to a summer-dry regimen after seedling establishment; moisture requirements are low. Composition of meal after oil extraction: protein, 50.7%; ether extract, 22.9%; ash, 8.5%; fibre, 4.6%; N-free extract, 25.3%, Methionine and lysine limiting amino acids.

Fruit is a wafer-thin achene; shattering and maturity over a prolonged season are both problems. Also trouble with pests and diseases. Presence of lipolytic eniyme in crushed seed necessitates prompt extraction to produce oil of low f.f.a, content. Considerable agronomic research, especially breeding and selection, required: yields vary considerabiy, but can reach about 900 kg/ha.

Barclay and Earle, 1965 Binder *eta!.,* 1964 Duisbeng and Hay, 1971 Earle er»**/., 1960q Earle *er al.,* 1964 Etten *et* a!., **1961 Jones and Wolff, 1960a Jones and Wolff, 1960b Knowles ef a/., 1964 Knowles *et a!.,* 1965 Rheineck and Sobol. 1963 Smith *st a!.,* 1960 Willingham and White, 1973**

109, *Dimorphotheca zeykeri* **Sond,**

Native of S. Africa, especially around the Cape.

Seeds contain (hull-free basis) 42% protein and 36% oil -which has iod. val., 130; conjugated acids: diene (dimor-phecolic), 43%; triene, 2%. Hence a possible industrial oilseed and source of dimorphecolic acid (iee entry no, 107).

Mainly restricted to semi-arid summer-rainfall areas.

Barclay and Earle, 1965 Earle era/., 1964

110. *Dioscorea elephantipes* (L'Her.) Engl.

(formerly *Testudinaria e/ephanripes).*

(Elephant's foot; Hottentot bread; yams (various *D.* species))

S. Africa, especially rocky semidesert areas of the Cape.

Source of sapogenins, particularly diosgenin (precursors for steroid drugs). Ore of the first sources of diosgenin to be exploited.

Yields large tubers, which can weigh up to 350 kg or more, having a diosgenin content of up to 4,5%.

Albans, 1956 Coursey, 1967 Dyer, 1955

International Trade Centre, 1974 Martin, 1969 Martin, 1972

Grows too slowly to be cultivated commercially. Natural supplies in danger of exhaustion due to over-exploitation. Other *Oioscoraa* spp, and other natural sources being exploited, The diosgenin is extracted in the country of origin, notabiy Mexico. *Sea* also next entry.

List of plants tolerant of arid or semi-arid - Part 31

Name(s)/Distribution	Current/past uses	Potential	Constraints	Citation data
111. *Dioscorea sylvatica* Eckl. (formerly *Testudinaria sylvatica* (Eckl.) Kunth) S. Africa, particularly the Transvaal around Lydenburg.	Source of sapogenins, particularly diosgenin (precursors for steroid drugs). One of the first sources of diosgenin to be exploited.	Yields large tubers, which can have a diosgenin content of up to 6%.	Natural supplies are now protected to help prevent over-exploitation; but other *Dioscorea* spp. are now being exploited, some of which are being cultivated and therefore yielding more certain supplies. In addition, sapogenins are also being obtained from other sources, e.g. *Agave* spp. (which have the advantage of yielding a fibre as well: *see* entries 7–21); and the world demand for most natural sapogenins is nowadays threatened by the spread of 'synthetic' (microbiologically derived) steroids (although there may still be a small demand for the naturally obtained sapogenins locally in developing countries from small firms lacking the technology for making 'synthetics').	Albans, 1956 Asolkar *et al.*, 1979 Blunden *et al.*, 1971, 1975 Coppen, 1980 Coursey, 1967 Dyer, 1955 International Trade Centre, 1974 Martin, 1969 Martin, 1972
112. *Duboisia hopwoodii* F. v. Meull. (Pitur.) Endemic to Australia – SW. Queensland, S. and C. Australia, and the drier parts of W. Australia.		Possible use crude as a natural insecticide or as a source of nicotine. Thus the leaves and twigs contain nicotine and/or nor-nicotine up to about 5%. Samples from W. Australia and SW. Queensland usually contain nicotine, those from S. and C. Australia, nor-nicotine.	Possibility of exploiting natural stands, and cultivating the trees, as a natural source of nicotine for use in insecticides was investigated in the 1940s: when it was concluded that other sources of nicotine were likely to be more economic. In addition, use of nicotine, a poison, nowadays discouraged.	Chopra *et al.*, 1960 Barnard, 1952 Bowen, 1944

List of plants tolerant of arid or semi-arid - Part 32

113, *Dubois/a teichhartii* F. v. Meull.

(Corkwood tree}

Endemic to Australia.

A drug plant which ii used as a source cf troparte alkaloids, particularly hyoscvs^ihe (from which atropine can be made). The plant is very drought resistant and is now being grown commercially in Australis to supplement supplies from natural stands — and also to supplement supplies of drug material from the closely related, but not drought resistant, speciesD, *myoporoides* R. Sr.

Leaves contain on average about 3% total alkaloids consisting mainly of hyoscyamine but hyoscine, butropine and valtropine are also present. Plant is very drought resistant.

When tried experimentally in India, the seeds did not germinate. Competes with Egyptian henbane *Hyo-xyamus mu tic us* — entry no 176).

Barnard, 1952

Berens, 1953

Carr, 1974

Chopra *et at*.. 1956

Griffin era/,, 1975

Rosenblum and Taylor, 1954

114. *Fmblica officinalis* Gaertn, [f]

115. *Ephedra alata* Decne."

C. and S, USSR, Arabian and Sahara deserts.

Green twigs possible source of the alkaloids ephedrine and pseudoephedrine (the latter being an isomer of the former and with essentially similar properties: *see* next entry). Thus samples of Moroccan twigs reported to contain up to 1 *%* pseudoephedrine (but Egyptian plants 50% lessl.

Not considered to be of value, except for local use, As noted left, alkaloid content rather low and varies widely with location.

Abdel-Wahab era/,, I960 Paris and Dillemann, i960 Reader, 1951

11Q. *Ephedra eqursetina* Bunge (Horsetail ephedra, mupen or murtse ma-huang),

Chopra *et a!.,* I960 Hu, 1969

Paris and Dillemann, Reader, 1951

1960

Mountain deserts and semi-deserts of Asia (especially China!.

Green twigs source of the alkaloid ephedrine, a vasoconstrictor with adrenaline-like stimulant and also decongestant activity; used In the treatment of asthma, bronchitis, renel colic, etc. Wild plants used extensively in Chinese medicine.

Total alkaloid content of up to 3% has been reported but average is 1,8% (1,6% ephedrine and 0,2% pseudoephedrine) Alkaloid content increases from spring to autumn and varies with altitude. Was cultivated successfully on an experimental scale during the late 1930s.

Alkaloid content varies with season and altitude *{see* left), In addition,)ike all natural sources of ephedrine le g. entry nos. 117, 119,120) this species is facing increasing competition from synthetic material and more efficacious drugs, and the outlook is not promising.

***■ Various *Ephedra* spp. are widely distributed throughout the warm, dry regions of the world, but only those containing significant quantities of ephedrine or pseudoeptiedrine *(see* entry no. 115) are listed. [f] denotes a potential firewood source (see Introduction)**

List of plants tolerant of arid or semi-arid - Part 33

117. *Ephedra gerardiana* Wall, ex Stapf; syn *£ vulgaris* Hook f. non.

A. Rich.

Endemic to the mors arid, mountainous areas of the northern SE. Asian sub-continent, particularly Baluchistan (5W, Pakistan), Normally found at altitudes of between 2,000 and 4,200 m.

One of the principal commercial sources of natural ephedrine (seeentry no. 116). Thus is grown commercially in Baluchistan and processed at Quetta. Consumption of crude drug in 1960s estimated at about 1,000 tonnes p.a. when Pakistan was the principal commercial supplier of natural ephedrine.

Total alkaloid content of dried green twigs is 1.0-2.5% Ihighest in the autumn) of which 60—70% is normally ephedrine and the rest pseudoaphedrine, Waste obtained after commercial extraction of the alkaloids found to contain 36% fatty acids, including stearic and palmitic, a high molecular weight alcohol (C24—2S^4&— 53^' ant* about 3%sterol R and D has been under

taken to find a use for this waste material and its use as an emulsion for waterproofing hardboard and as a source of tannin, has been suggested. The plant has been successfully cultivated experimentally in Australia and Kenya.

1961

Plant is only found at high altitudes Use column 1) and alkaloid content adversely-affected by **rain. Future outlook not promising due to increasing competition from synthetic ephedrine, *see* entry no. 116, although may continue to be of local importance.**

AM and Ahmad, 1968 Chaudhri, 1357 Chopra era/., 1960 Chumbalov and Taraskina, Du13berg and Hay, 1971 Paris and Dillemann, 1960 Reader, 1961 Stddiqui and Hahn, 1959 Wright, 1960

118. *Ephedra intermedia* Schrenk Bi C. A. May.

(Chung ma-huang)

Sandy desert areas of N. Asia, generally at an altitude of 1,500—

2,000 m, but in very arid areas of Pakistan can occur at 2,700 m.

Dried green twigs contain alkaloids (mainly pseudo-ephedrine), Used in Chinese medicine — and sometimes also to adulterate commercial supplies of *E. gerardiana.*

Indian samples of dried green twigs reported to contain 2,3% alkaloids of which 1.8% was pseudoephedrine and 0.4% ephedrine: but Pakistan samples reported to have total alkaloid content of 1,5% or less.

Plant is only found at certain altitudes and both alkaloids can be obtained synthetically (see entry no. 116)

Chaudhri, 1957 Chopra *et a!.,* 1960 Hu, 1969

Paris and Dillemann, 1960 Reader, 1951

119. *Ephedra major* Host; syn.

E. nebrodensis Tineo 9k Guss.

1960

Northern SE. Asian sub-continent, Spain.

Closely resembles *E. gerardiana* and some authorities do not differentiate between the two. Used as a commercial source of natural ephedrine Use entry no. 116).

Indian samples of **dried twigs reported to contain *2.3%* total alkaloids, of which 1.9% was ephedrine,**

Same constraints as noted for entry no, 116,

Chaudhri, 1957 Chopra era/., 1960 Paris and Dillemann, Reader, 1951

120, *Ephedra sinica* Stapf (Tsaopen ma-huang)

Native of the drier areas Of **China.**

The principal Chinese species of *Ephedra.* Used as a commercial source of natural ephedrine ($90 entry no. 116).

Average total alkaloid content of green dry twigs, 1.3%; ephedrine, 1.1 %. In 1930s, the Chinese plants were an important commercial source of ephedrine in international trade, but superseded by supplies from Pakistan. Alkaloid content highest in the autumn.

Outlook not promising: *see* entry no. 116,

Chopra *eta!.,* 1960 Duisberg and Hay, 1971 Hu,1969

Paris and Dillemann, 1960 Reader, 1951

List of plants tolerant of arid or semi-arid - Part 34

Constraints

Citation data

Current/past uses

Potential

Nsmelsl/Distribution

121, *Eucalyptus dumOsa* A. Curtn. en Schae*

The higher-cineola specimens Yield of oil from foliage ebon Composition cineolet Eucalypti tend to denude

(Bull mallee'' |

Native of Australia (NSW, Victoria and S, Aujtralial.

have been used occasionally a; a source of medicinal eucalyptus oil, an essential oil used in pharmaceutical products.

(33—44%, usually but occasionally up to 66%) along with D-Gf-pinene, aldehydes, and sesquiterpenes. Has been suggested as a possible *Eucalyptus* species for arid lands. Multipurpose — also a possible source of fuel and, through its flowers, of honey (regarding tannins, *see* footnote*) surrounding ground of moisture (and store it in the roots where it can be used as a source of water), Nowadays only those eucalypt oils with at least 70% (e.g. next entry} cineole used as medicinal oil.

Paris and Dillemann, I960 Penfold and Morrison, 1950 Penfold and Willis, 1954 Penfold and Willis, 1961

122. *Eucalyptus fruticetonim*

F. Mueil;

syn. *E. potybractea* ft. T, Baker {Blue mallee[t]}

Native of Australia (W. NSW and the mallee district of Victoria!.

123. *Eucalyptus oleosa* **F. Muell Australia (NSW, Victoria, S. and W. Australia).**

Source of medicinal eucalyptus oil. Australian production in 1968 reported to be about SO tonnes but supplies likely to diminish unless plantations are established or natural stands upgraded. The principal 'mallee' eucalypt; in late 1960s it provided over ofie*third of Australia's eucalyptus oil.

Source of medicinal eucalyptus oil. Foliage usually distilled in admixture with other mallees.

Yield of at I from foliage 1.5—2.5%, depending upon season and age of tree. Composition of oil: cineolet 77—85%, plus p-cymene, cuminal, 4-isopropyl saltcylaldehyde lall three being Cm aromatics), L-Ct-pheUandrene, phellendr&l, cryptone, piperitone (related mo no terpen es). Also, as for antry no. 121, a possible source of fuel and of honey (regarding tannins, *sea* footnote').

See **entry no.** *re* **water use.**

121

Yield of oil 0,9-2.0% (average 1.4%I. Cineole content 54—80%, average, 64%. Also, as for entry no. 121, a possible source of fuel srid of honey (for tannins, we footnote *!. Has been suggested as a possible *Eucalyptus* species for arid lands, as it is very drought-resistant.

See **entry no. 121,**

Guenther, 1968 Penfold and Morrison, 1960 Penfold and Willis, 1954 Penfold and Willis, 1961

Paris and Dillemann, 1960 Penfold and Willis, 1954

*** In addition to those *Eucalyptus* species listed, *£, cnepn'folia* DC. and *E. viridis* R T Baker, are also exploited on a very small scale (the latter is alto mentioned by Paroda, 1979, as being an Indian AZ plant which yields an essential oil). Most also contain 10-20% tannins, sometimes more, in wood and bark but the arid-tolerant spp. are generally too small, too scattered and too low in tannins to make exploitation, except locally, worthwhile (Penfold and Willis, 1961). Several (£. *CBmaldulensis* Dehnh., *£, cixriodora* Hook, *E. gomphocephata* A.DC., f. *micro theca* F, MuelL, *E. occidental is* Endl.) have been identified as potential firewood sources (National Academy of Sciences, 1980: *see* Introduction).**

[+] Dwarf, stunted eucalypts known as 'mallees' occur in low rainfall areas of Australia.

i Strictly 1,8-cineole (a monoterpene, $C_{l0}H_{16}O$, containing an ether ring) — to distinguish from 1,4-etc. isomers.

List of plants tolerant of arid or semi-arid - Part 35

124. ***Eocarya spicaTa*** Sprague **& Summarh.**

(Australian sandalwood)

Native of arid area: erf W. and S. Australia.

125. ***Euphorbia abyssmtca*** J. ***F.*** Gmel[1] **syr. *£. erythraeae* N. E. Br.**

Sudan.

126. *Euphorbia antiquorum* L, {Triangular spurge [t])

SW. Asia, India.

Source of sandalwood Oil. used mainly in perfumery; formerly used medicinally.

Despite its Irritant nature, the plant is widely used in indigenous medicine, both internally (e.g, as a purgative and against gout) and externally (e.g. the latex is used on warn and to kill maggots). The latex is also used as a fish poison.

Yield of oil from butts and roots, 1.4-2.6%. More than 90% of oil consists of sesquiterpenes (calculated as C25H24O);ft-santalol chief constituent,

Seeds yield 33% of a drying oil, similar to linseed oil with sap. val., 190; iod. val., 1 77.7—179.2; unsap. matter,

1.8%:and fatty acid composition: linolenic, 53.4%; linoleic, 17.9%; palmitic, 13.8%; oleic, 9.2%; stearic, 5.2%; aracfiidic, 0.4M; myristic, 0.1 %. Analysis of late?; obtained by tapping: rubber, 9.0%; resin, 66%; insoluble matter, 11%. Potential oilseed: harvesting of the seed would be relatively easy if cultivated On a large scale; and the oil may then provide an alternative to linseed oil as the drying oil constituent of paints, varnishes, 'linoleum' etc. The plant could also perhaps be used as a source of rubber.

A saline extract of the stem has anti-bacterial action. Latex contains 4.0— 6.4% rubber, Following compounds (all trite rpenes) isolated; from the stems — taraxerol. friedelan -30c-and 3^-ols and taraxerone; from the latex — ^smyrin, cycloartenol, euphol and Os-euphorbol; (but *sea* also footnote*); from the roots — taraxerol.

Oil considered to be inferior to'East Indian' (from *Sanra/um album,* S. India) sandalwood oil. Production understood to be declining owing to over-exploitation.

Latex very irritant'.

Guenther, 1 952 Penfold and Willis, 1954 Walker, 1966

Barker *etet,,* 1950 Henry and Grindley, 1944 Sudan, Report of the Government Analyst, 1942

Anjaneyulu era/., 1967 Anjaneyulu and

Hamachandra Rao, 1971 Chopra *eta!,,* 1960 CSIR India, 1952 Sen Gupta and Ghosh, 1964

*** The *£upftortiie* is a very large genus (over 200 species) of lacticiferous herbs, shrubs and $mal1 trees vvhich are drought resistant and found in the arid and semi-arid regions. Most fiave the disadvantage, which acts as a major general constraint on their utilisation, that the latex which exudes from the leaves or stems on cutting contains substances [identified as esters of the tetracyclic diterpenes phorbol, ingenol and allied compounds (Evans and Soper, 1978; Hecker, 1977; Upadhyay *eta!.,* 1976) occasionally varying with the plant's location (Furitenberger and Hecker, 1977; Kmghorn, 1979) which are powerful skin irritants causing severe inflammation, particularly to the eyes, and which also act as cocarcinogens (i.e. accentuate the cancer-causing activity of any true carcinogenlsl present). Those species listed here whose latex has been shown to have irritant activity in a standard test include entry nos- 125. 126, 132, 133. 144, 146, 150, 151,1 55, 157, (all very active, especially nos. 1 50 andlBI) and nos. 145 and 152 (moderate); nos, 129 and 141 showed little activity and the remainder were not included in the study (by Kinghornand Evans, 1975). Not surprisingly, consumption of various parts of**

Euphorbia sp. has on occasion caused illness, and sometimes death, in both animals and humans (Watt and Breyer-Brandwijk, 1962). The 'euphorbium' and 'euphorbone' derived from latex (or resin) are not chemical entities but mixtures: cf. McDonald _eta!.,_ 1949.

* *Euphorbia* **spp. in general are often known locally as spurge or devil's milk.**

t Despite the comments under*, certain phorbol derivatives of the kind found in _Euphorbia_ spp. show anti-cancer activity (Kupchan, 1976; Ogura _etai,_ 1978; _see_ also under entry no. 151).

List of plants tolerant of arid or semi-arid - Part 36

Citation data

Constraints*

Current/past use?

NarneUJ/Distribution

127. *Euphorbia antisyphilitica* Zuce.; syn. *E. ceriiera* Alcocer

(Candetilia, jumBte)

USA - SW. Texss, S. New Mexico, Arizona. California;and N, Mexico.

Commercial so urea of can-delilla wax. used extensively to harden other waxes, as a substitute for carnauba wax and has similar industrial uses, e.g. in polishes, moulding arid adhesive compounds, chewing gum, lubricants, plastics, cosmetics, explosives, insulators etc.

The (leafless) stems contain 2.5—5% wax — with m.p,

66—71°C; tap. vaL, 47-64; acid val., 12.3—20.6; iod. val., 19—44; on the basis of 67% unsaponifieble matter, the composition appear; to be about: eaters of hydro xylated acids, 33—35% (primarily si tester o! combined with dihydroxymyricin-olaic acid); lactone, 5—6% (hydroxy-myricino-lactone); free acids, 9—10%; hydrocarbons, 50—53% {hantriacontane, tritriacontane). The wax said to have a 'valuable industrial potential[1], especially if the plant could be domesticated and improved wrax-extraction procedures devised (said to appear easier to mechanise harvesting and production of this wax than carnauba, its main competitor). With industrialised processing, the waste might be used for paper pulp.

Latex reported to contain a proteolytic enzyme, euphorbain.

Considerable R and D effort needed to develop commercial cultivation and improve processing: with current primitive processing techniques extraction rate of wax is only about 2%. Extraction process requires an adequate supply of water. Like carnauba wax, suffering from competition from synthetic waxes. Production from natural standi is dedining in Mexico, the major producer. Attempts to cultivate the plant outside its native habitats have mainly been unsuccessful and cultivated plants said to yield less wax than wild strands.

Castaneda sr a/., 1943 Daugherty er a/,, 1953 Duisberg, 1952a, b Duisberg and Hay, 1971 Hernandez, 1970 Hodge and Sineath, 1956 Kroner, 1961 McNair, 1954

National Academy of Sciences,

1975 ParOda, **1979 US Government, 1957**

128. *Euphorbia Btoto* Forst.f. syn. *E. dale is* Blanco Tropical Asia, especially SE. Asian sub- [arKl] fbortifacient. continent.

Latex used in indigenous medicine, as an emmertagogue

An alkaloid, <+)-9-aia-1-methylbicvc!o (3:3:11 nonan-3-one, isolated.

Beecham *et a!..* 1967 Hart« a/., 1967 Uphof, 1958

129. *Euphorbia balsamitera* Ait. {Balsam spurge)

W. Africa, Canary Islands.

Used in indigenous medicine, particularly in veterinary medicine for the treatment of horses. Commonly grown for hedging. Latex investigated in 1940s as a source of rubber.

Latex yields t5-2B% coagulum, which consists of 84% resin, 12% rubber and 4% insoluble material. Latex also contains traces of an irritant, cocsrcinagemc compound, 12-deoxyphorbol. German ico I,garmanicone, lupeol, lupenone,f)-amyrin, cycioartanol, dihydroagnosterol and cycloartanone also feported in latex. The rubber could be used as a plasticizer for rubber mixtures; coagulum itself also of interest, rubber. Irritant compounds a serious handicap to the exploitation of the tree;* also its prickly nature.

Rubber very inferior to *Hevea* Calvin, 1978

Compagnon, 1943 Daliiel, 1948 Evans and ttmghorn, 1975 Gonzalez iff a/.. 1976 Le Bras, 1943

'For genera) points concerning the *Euphorbia* spp,, rse footnote* on p.39.

List of plants tolerant of arid or semi-arid - Part 37

130. *Euphorbia catycina* NE. Br. (See also under *E. candelabrum)* Sudan.

131. *Euphorbia calycu/ata* Kunth

IChupire (n)t

Mexico.

132- *Euphorbia candelabrum* Trem.

ex Kotschy;

syn. *E. catycina* NE, Br,

Africa, especially Eritrea and the Sudan.

133. *Euphorbia desmondi* Keay & Miine-Redhead

W. Africa.

134. *Euphorbia (jrgcitncufoides* Lam, (Haunchee, titleel

SE. Asian sub-continent, tropical Africa.

Ripe fruit contains smal I seeds, which yield 'fixed' (fattyl oil. Tapping of tree yields resinous latex, reported to be used as an insecticide in E. Africa.

Exploited as a minor source of natural rubber in early 1900s.

A tree up to 50 ft (16 ml in height. Plant extracts sometimes used in indigenous medicine.

Grown for fencing; latex used locally as a fish poison.

Source of the indigenous drug 'sudab' — which is used medicinally.

Fruit contains 14-16% seeds, oil content, 21—25%, Oil has sap. val., 189; iod. val, 189—192: fatty acid composition: linolenic, 60—66%; linoleic, 9-12%; oleic, 2-19%; palmitic. 11%; stearic, 1 2%. Latex contains rubber, 7.3—11.3%: resin, 61,9%; insoluble matter, 26.729.9%. Examined during World War II as possible source of natural rubber. The oil is even more unsaturated than linseed oil and so may have potential as a drying oil for paint etc: properties approximate those of conophor oil (from *Tetracarpidium conophorum,* West Africa).

Latex yields 21% of good-quality rubber.

Fruit contains 14% seeds, oil content, 21%. Sap, val.,

189; linolenic acid, 42.5%; linoleic, 37,5%; oleic, 12,5%; saturated acids, 7.5%. Latex contains 50% rubber, around 14% gum and some wax. Investigated during World War 11 as a possible oilseed; also considered a possible source of natural rubber.

A glycoalkaloid, euphorbine, reported in the stalk and leaves. Euphorbol la triterpene), sucrose and a flawone-glycoside, kaempferol, also isolated from the stalks and leaves. Seeds contain 0.28% phenolic substance (m.p. 268? C}. kangiol; also 25—23% yellowish-brown oil with sap. val., 200; iod, val., 1 72,6; acid val., 26.3; unsap. matter, 2.65%; and fatty acid composition; oleic, 30.5%; linoleic, 23,6%; linolenic, 8.6% betienic, 0.6%; arachidic,, 5.3%; stearic, 15,3%; palmitic, 7,1%; myristic, 0.3%. Hence a potential drying oil *or use in paints etc.

Sparsely distributed; would have to be cultivated systematically in order to produce oil in quantities sufficient for commercial exploitation.

Latex contains about 1% ingenol, *a* cocarcmogenic irritant*.

Considerable variation in the reported oil constants. Unsaturation barely high enough for reliable use as linseed oil substitute (need; an iodine value of at least 175 to 180).

Barker *et a!.,* 1950 Henry and Grindley, 1944 Sudan, Report of the Government Analyst, 1942 Vanderpiank, 1945

Uphof, 1968

Dale and Greenway, 1961 Kokwaro, 1976 Polhamus, 1962 Sudan, Report of the Government Analyst, 1942 Watt and Breyer-Brandwijk, 1962

Evans and Kinghorn, 1973 Evans and Kinghcrn, 1975 Kinghornand Evans, 1974

CSIR, India, 1952 Pal snd Dutta, 1969 Singh and Singh, 1959 Singh and Srivastava, 1966 Singh er *at.*. 196S

For general points concerning the *Euphorbia* spp., fee footnote* on p. 39.

List of plants tolerant of arid or semi-arid - Part 38

135. *Euphorbia echinus* Hook. f. Si Cots.

N. Africa, SW. Africa INamib desert).

Audy, 1942

Ruiz and French, 1948

Rubber content of latex reported to be 2.67%; resin content 18.8%. Hence a possible source of rubber.

Rubber content probably too low for economical extraction.

136, *Euphorbia fiha* Dec. IFihs)

Madagascar.

137, *Euphorbia fviva* Stapf; syn.

E. elastica **Alt. & Rose**

(Palo amarillo, palo Colorado, palo cucaracha, papelillo)

Mexico.

138, ***Euphorbia gregarw*** **Marloth SW. Africa.**

139, ***Euph orbia gymnodada*** **B o i ss, Brazil.**

140. ***Euphorbia heterophytla*** **L. (Painted spurge, cstalina) Mexico.**

Minor source of rubber; used locally for preparation of varnish and as *a* source of max lobtained from the leaves).

Exploited as a minor source □ f rubber in early 1900s and during World War II.

Source Of bslflta (a guttapercha-like plastic material obtained on drying the latex obtained from the wood). The wood is also extensively used for firewood.

Said to be used in indigenous medicine as an antidote to the irritation caused bv other *Euphorbia* spp.; but shows acute toxicity in substantial quantities.

Trees can be tapped for their latex three times a year for about 10 vears. Rubber content of latex, 18—20%, resin up to 40%. Oil content of seeds, 30%, suitable for soap manufacture (and perhaps as a drying oil); residual Oil cake high in protein.

Possible oilseed (seeds contain 42% oil) and source of poor-quality rubber.

B a lata reported to have 17% gutta content. Has been suggested that the fibrous residue remaining after removing the latex from the wood could be used as a source of paper pulp,

Seeds contain 25% protein and 37% oil; this has sap. val,, 188, iod. val., 200, and fatty acid composition: linolenic, 55%; linoleic, 22%; oleic, 10%; saturated acids, 8%. Hence a possible source of drying oil liod. val. well over the 175—180 threshold: *see* entry no. 134).

Latex very irritant, especially to the eyes. Rubber difficult to extract because of high resin content of latex.

The balata obtained is of poor quality (normal commercial material has 50%, and sometimes up to S0%, gutta).

Lysine the limiting amino acid in the oilcake.

Decary, 1946 Decary, T962

Uphof, 1945 Zinser, 1941

Mensier, 1957

Watt and Brayer-Brandwijk, 1962

Mors and Rizzini, 1966

Earle era/., 1960b Etten van et *al.,* 1961 Watt and Breyer-Brandwijk, 1962

For general points concerning the *Euphorbia* spp., see footnote * on p. 39.

List of plants tolerant of arid or semi-arid - Part 39

141. *Euphorbia htrtB* L.; syn.

E. pHuttfers **auct. non L.**

(Spurge, betsim, rnerina, snakeweed herb, Indian wolf's nriilkh

Probably originated in Africa but now widely distributed (particularly in Australia, E. Asia, Brazil and Mexico}.

142. *Euphorbia* ***irttisy*** Drake

flntisy, herotra)

Madagascar; introduced experimentally into **USA** during fatf; 1920s.

143, *Euphorbia lagsscae* Sprang, Native to arid region of SE. Spain: introduced successfu'ly into the USA (Arizona and Ca'ifbrnia),

S. America.

* For general po.rits concerning the *Euphorbia* spp., *see* footnote * On p. 39.

List of plants tolerant of arid or semi-arid - Part 40

Used in indigenous medicine in Africa and India. Contains an anti-spasmodic principle and has been used widely for the treatment oi asthma and bronchitis. Has a galactogenic action. Used also for dysentery.

Source of rubber.

Grown as d winter annual in ttie USA,

An approximate analysis of plant material reported as: fat, 1,0%, sterols, 0.4%; resins, 2.6%; reducing sugars,

1,7%. Presence of L inositol, quercitol (sugars), quercitrin Iflavonel, taraxerone, taraxerol, Of- and *8*- amyrin, friedelin, campesterol, stigmasteroi, sitosterol (common plant triterpenes and sterols), hentriacorttane and succinic, fumaric and eflagic acids has been reported. Further investigation of the therapeutic action considered to be worthwhile; non-irritant extracts with wide therapeutic activity said to have been prepared.

Rubber is of high quality — best of the ***Euphorbia*** spp. Heavi'y exploited during the rubber boom in early 1900s (plants almost exterminated). Reported that it can be grown easily from seed.

Seeds **contain:** protein, **21-26%;** oil, **42-50% —** which has sap val., **188;** iod. val., **91.7—92.7;** unsap. matter, **0.71 %; vernclic** acid **(CM—12, 1** S-epoxy-eis-S-octade-cenoic), **58-62%.** Potential industrial oilseed; source of vernolic **acid** {used **in** plastic formulations, protective coatings, etc.).

Plant yields very little latex.

Some doubt concerning the age at which the plant can be tapped for rubber.

Disease and nematodes are a problem in US operation, Seed yield 950 kg/ha or less. Need to develop strains with better seed retention. Steam heat necessary to inactivate enzymes, during oil extraction.

Ayensu, 1979

Blanc and De Sfrqui-Sannes,

1972 Caldwell, 1966 Chopra *era!.,* 1960 Gupta and Garg, 1965 Gupta and Garg, 1966a Hallett and Parks, 1951 a, b HalleTt and Parks, 1953 Kinghorn and Evans, 1975 Rakoto-Ratsimamanga e(*sL,* 196S Steinmetz, 1964

Anon, 1930c Decary, 1962 Polhamus. 1962

Kleiman *et a!.,* 1965 KrewsCn and Scott, 1966 Scott and KrewsCn, 1966 White and Wolf, 1568 White *eta!.,* 1971

144. *Euphorbia lathy ris* L. (Gopher plant, caper spurge, oily milkweed, myrtle spurge, and petrol tree lalso used for *E. tirucail/))*

Asia, Europe, USA (especially N. California).

145. *Euphorbia neriitoHa* L.;syn *E, /igularia* Roxb., *E. penOgona*

Blanco

Tropical Asia, especially SE. Asian su b-conti ner>t.

146. *Euphorbia nivuiia* Buch. Ham,

Dry rocky areas of SE, Asian subcontinent; also reported in Burma and dry forests of Peru,

Long cultivated in China for medicinal purposes and as a

fish poison.

Latex and leaf extract used in indigenous medicine. Leaves sometimes used as a fish poison.

Latex, leaf extract and root bark all used in indigenous medicine.

A potential industrial oilseed (Occurs as a biennial vueed in the USA), Experiments indicate seed yields of 1,700—

2,000 kg/ha attainable. Seeds contain: protein, 14—

17%; oil, 48—50%. The letter has sap. val., 197; iod, val., 82—89 and fatty acid composition: oleic, 84.3—90,0%; linoleic, **2.3-7,0%; saturated acids, 5.7-7.7%. Oil strongly purgative and so unsuitable for edible purposes, but produces a high-grade soap. A number of compounds (e.g. 6, 20-eppxy lathyrpl, and the bicoumarin, «uphorbetin) hav* been isolated from the oil. In addition, ingenol 3-hexadecanoate and 3-tetradeconoata, which have** cO-

carcinogenic **activity*, have been isolated from the oil and from the plant iatex. Leaves and flowers contain 18% resins and 0,15-0,26% of a rubber-like material. Seed hulls can be used for preparation of furfural. It has been suggested that by cultivating as an annual and harvesting the whole plant (mechanically), the equivalent of around 15 barrels crude fuel oil/ha p.a. could be obtained** — even **using non-improved Mild seed. Linder trial in Israel yield of 68 7g/m^2/yrof** hexane-**extractables obtained from leaves and stem.**

Latex contains 0.2—2.6% rubber. Euphol, nerifoliol, friedlan-3|Jand 3<J-ols, taraxerol, and gtut-5(10)-en-1-one (all triterpenes) reported in plant tissue.

Latex contains about 1% rubber. Bark is suitable for making composite cork boards, hardboard, etc.

Needs a period of cold to flower. In the USSR germination has been found to be uneven, but improved lines capable of being harvested mechanically have been developed. Oilcake too toxic for use as animal feed. Said (in 1977> to be many unsolved problems especially as regards extraction of the latex (? by crushing or by solvents! for fuel,

Latex reported to cause dermatitis, etc.*.

Latex is reported to cause dermatitis, etc", An aqueous alcohol extract of the aerial parts medicinally inactive in a wide range of tests.

Adolf and Hecker, 1971 Adolf and Hecker, 1975 Adolf *eta!.,* 1970 Anon, 1977b Aronson and Zur, 1982 Buchanan era/., 1978b Calvin, 1978

De Parcevaux and Allirand,

1977

Dublyanskaya, 1937 Duttaera/., 1972 Gardener, 1982 Grynberg *ex ai.,* 1962 Johnson and Hinman, 1980 Kester, 1949 Kleiman *eta!,,* 1965 Narayanan *eta!.,* 1971 Schroeder er *at,,* 1979 Tyutunnikov *et a!.,* 1935 Wang and Huffman, 1981 Zechmeister *et a!.,* 1970a and b

Anjaneyulu and Ramachandra Row, 1965 Anjaney ulu *et* a/., 1973 Chopra *eta!.,* 1960 CSIR India, 1952 Nagesware Rao and

Ramachandra Row, 1966 Watt and Bfeyer-Brandwijk, 1962

Ayensu, 1979 Chopra *et a!.,* 1960 CSIR India, 1952 Narayanamurti, 1952 Marayanamurti and Singh, 1954

*** For general points concerning the *Euphorbia* spp..see footnote* on p. 39.**

List of plants tolerant of arid or semi-arid - Part 41

147, *Euphorbia officinarum* L. (Gum thistle I N. Africa.

A source of gum euphcrbium used mainly as a vesicant in veterinary medicine. Plant investigated as a possible source of rubber in 1940s,

Chief constituents of the gum $_{r}$ or coagulum, are resin, wax, lignin, bassorin, salts of malic acid and a volatile oil.

Very irritant: workers reciuire protection from Ihe dust when collecting and packing the gum.

Grieve, 1976

148 *Euphorbia pbosphores* Martius

(Candomble, cipo cunanann. cipo de **hreu h**

Brazil (Bahia and Piauii.

Source of a wax resin. At one time plant poi/vder used locally for domestic lighting, as a substitute for kerosene and for soap manufacture. Latex tias been used in ihe manufacture of chewing gum; and resin was utilised during World War 11,

The wax resin could probably be used in the preparation of tarnishes, based on drying oils, and adhesives. It has the following characteristics; acid val,, 41,3; sap. val.,

Carra?zom, 1966 **Rosenthal. 1954**

100.7; softening point, 91 — *92*0,* m.p., 134-141' C, Lupaol, lupenone taraxerone, taraxerol acetate and clean— 13(18)-erv3-one (triterpenes) have been reported in the plant.

At one time latex was exported to the USA, but ceased because of high cost of extraction. Resin examined in early 1950s, but considered to have 3 very limited commercial potential. Latex causes dermatitis.

149. *Euphorbia pirahaio* Jum. Madagascar.

150. *Euphorbia poisonii* Pax {Candle plant, Tinya)

W. Africa.

Latex used in indigenous medicine, and as a counter-irritant drug; also as an insecticide and fish poison.

At One time exploited as a source of rubber which was reported to be of good quality.

Perrier de la Bathie, Polhamus, 1962 Uphof, 1968

1949

Four chemically related diterpene toxins have been isolated from the latex: *a* 12-deoxv-4$.hvdroxphorbol and

its 20-acetate, resiniferatoxin (fee next entry) and tinyatoxin, the last two compounds being the most potent toxins so far obtained from the Euphorbiaceae.

Plant now very tare owing to Over-explaitatiQn,

Latex can cause skin lesions Dalziel, 1948 and inflammation o(the mucous Evans and Kinghorn, 1975 membranes; and chronic Evans and Schmidt, 1976

exposure is reported to cause Ftecker, 1977 blindness.* Schmidt and Evans, 1975

Schmidt and Evans, 1977

'For general points concerning the *Euphorbia* spp., *see* footnote" on p.39.

List of plants tolerant of arid or semi-arid - Part 42

151. *Euphorbii resinifera* Berg. (Euphorbium)

N. Africa, especially Morocco.

152. *Euphorbia royleana* **Boiij. (Thor}**

SE. Asian sub-continent.

153. *Euphorbia thi* Schweinf. Tropical Africa, especially[1] in the Sudan and Somalia.

Dried latex is a source of the commercial drug euphorbium

— used, mainly in veterinary medicine, as a counterirritant drug.

Used in indigenous medicine as an anthelmintic and cathartic; also used as a fish poison,

Latex contains 33—36% sotids, of which 6—8% rubber,

40—51% resins, 28-30% waxes, 11% water-soluble compounds (pectin and protein, 4,8—7%). Latex also reported to contain: phorbic acid (a water-soluble Cs-acid), euphol, euphorbol, taraxol, resiniferol, [all triterpenes), an irritant diterpene ester, resintferatoxin. Latex investigated during 1940s as a possible source of rubber. (—)-quinic acid, □{■M-Q-bydroxyglutaric acid, myoinositol, Ll — l-inositol and probably vanillic acid have been reported in crude euphorbium. Certain fractions in the resin have shown promising anti-tumour activity.

Fresh latex has a rich sweet odour. Reported to consist of 64-80.6% water and water-soluble compound) and 1,0-5.4% rubber. Euphol, cycfoeucalenol, sitosterol, taraxerol, epitaraxerol, glut-5-en-3jJol (all triterpenesl, eilagic acid and 3, 4-benzoeoumarins reported present in the latex. Tsrsxerol also present in stem tissue and ellagic acid in the flowers.

Latex contains6.8% rubber and 61,2% resins. Plant investigated during World War (I as a source of rubber.

Workers collecting the crude coagulated latex have to be protected becausc it is so acrid. Certain fractions in the resin are reported to be carcinogenic, for utilisation as a source of rubber, it was found essential to remove all the resin and to purify if one is to obtain a satisfactory, durable rubber, The prickly nature of the plant and the vesicant properties of the latex* are a considerable handicap to its commercial exploitation.

Latex is reported to cause dermatitis and to be injurious to the eyes." Plant extracts irritant.

Audy, 1942 Bernatek er *al.,* 1963 Boe *et a!,,* 1969 Chopra *et at.,* 1960 Compagnor and Ziller, 1942 Dupont *at at.,* 1947 Dupont *at at.,* 1951 DupOntSfa/., 1953 Hecker, 1977 Hergenhahn *et at.,* 1975 Kopaczewski, 1946 s. b La vie ef *el,,* 1963 Le Bras, 1942

Anjaneyuiu *at at.,* 1974 Ayensu, 1979 Chopra ef *si.,* 1960 CSIR India, 1952 Ghosal ef *a!.,* 1976 Nazir *at at.,* 1965 Nazir *et a!.,* 1966 Sengupta and Ghosh, 1965 Stiarma *era!.,* 1964b

Sudan, Report of the

Government Analyst, 1942

154. *Euphorbia thym!folia* L.

Widely distributed in the tropics, especially Asia.

Used in Indian indigenous medicine for treatment of asthma, bronchitis, skin diseases, etc. The essential oil present is used as an insecticide and vermifuge and in medicinal soaps.

Taraxerol, tirucallal (triterperesh a C30 wax alcohol (myricyl alcohol I and hentriacontane identified in plant extract. Presence of antimicrobial alkaloids has been reported. Stem and leaves contain free fumaric acid and 5, 7, 4'trihydrcxyf lavone-7-glycoside, Essential oil has a pungent odour and irritating taste; its constituents include carvacrol, limonene, various sesquiterpenes and salicylic acid.

CSIR India, 1952 Gupta and Garg, 1965 Gupta and Garg, 1966b Jabbar and Khan, 1964

'For general points concerning the *Euphorbia* spp,, *see* footnote* on p.39.

List of plants tolerant of arid or semi-arid - Part 43

Potential

155. *Euphorbia tirucaili* L.; syn. *E. scnparia* NE. Br.

(Milk bush, Indian tree spurge, petrol tree (also used for f. *lathytis),* potato gum tree, finger euphorbia!

Native of Africa, but now widespread in the drier parts of the tropics, especially in the SE. Asian subcontinent.

156. ***Euphorbia trigona*** Haw. (said[1] to he synonymous with ***E, neriifolia*** (q.v.}; Walt and Breyer-firandwijk, 1962I

SE. Asia,

157. *Euphorbia unrspirta* NE. Br. (Candle plant)

W. Africa.

Shrub or tree grows to 20 ft (6 m). Commonly grown as a hedge plant (partly because the irritant latex acts as a deterrent). Latex, roots and branches used in indigenous Imainly external) medicine in Africa and Asia, and as a fish poison. Attempts made to utilise the latex as a commercial source of rubber in South Africa during rubber boom of early 1900s and World War II, and (during World War ||) to utilise the resin present in the latex.

Leaves and latex used in indigenous medicine,

Latex used in indigenous medicine as a counterirritant drug and as a fish poison. Often grown as a hedge plant (Uee entry no. 155) and other *Euphorbia* entries).

Chemical composition of latex varies according to origin and to some extent whether fresh or dried. Analysis ol S. African latex: moisture, 51.3%; rubber, 8.3%: resinj; 30.4%; impurities, 4.0%, ash, 6.0%. Rubber, which is stable to paling and aging, has lower tensile and higher elongation values than *Hevea* rubber. Resin has acid val.,

3,5—9.5; sap. vgl,, 41—47; m.p., 51 B0°C. In addition to the irritant deoxyphorbols (and/or analogues), latex contains euphol, taraxasterol and tirucsllol (triterpenes). Stems contain hentriacontane, hentriacontanol (waxes), (j-sitosterol, taraxerol Itriterpenes), kaempferol (flavone), ellagic acid (a phenol) and its 3, 3-dimethoxy derivative, Plant has been suggested as a source of papermaking material mixed with bagasse and sisal; and is currently being investigated as a possible source of fuel^ (e g by OA LS, Arizona I Davis, 1978a) and by Calvin I - in this case, in contrast to *E. tatbyris* (q.v.), by tapping the mature tree. Plant and extracts said To show insect-deterrent activity.

Latex contains resin, malic acict and rubber (1,5%). Vegetative parts are reported to contain hydrocyanic acid.

Latex is a potent cocarcinogen *(see* footnote' for definition I, very irritant to mucous membranes and difficult to handle, which handicaps any commercial exploitation*. High cost of harvesting and difficulty of extracting the rubber, because of the high resin content of the latex, made exploitation in S. Africa uneconomic.

The rubber manufactured from the latex is said to be of low grade and the resin to be unsuitable for making varnish as it lacks durability. Many problems with obtaining a fuel *{see* entry no. 144).

The latex is acrid and vesicant (see comment left *re* HCN content).

Latex is very irritant to skin due to the presence of aliphatic esters of 12-deoxyphorbol, especially resiniferatoxin,*

Anon, 1942t

Anon. 1943b

Anon, 1944b

Anon, 1977b

Calvin. 1978

Chopra *et a!.,* i960

De Parcevaux and Allirand, 1977

Dutta and Karimullah, 1944

Furstenberger and Hecker, 1977

Gopalachari and Siddiqui,

1949a, b Gupta and Mahadevan, 1967 Haines and Warren, 1949 Karimullali and Gopalachari, 1949 Kinghorn, 1979 Kopaczewski, 1347 Martin, 1944 McDonald er *ai.,* 1949 Seelkopf et *a).,* 1959 Vanderplank, 1945 Wang and Huffman, 1981 Watt and Breyer-Brandwijk,

1962

Badhwar er a/., 1946 Burkhill, 1935 CSIR India, 1952

Evans and Kinghorn, 1975 Hecker, 1977 Hergenhahn *etal.,* 1975 Schmidt and Evans, 1977

*For general points concern ing the *Euphorbia* spp., *see* footnote* on p.39. t*ee *Asclepias* spp.

List of plants tolerant of arid or semi-arid - Part 44

158, *Fallugta paradox a* (D. Don) Gndl.; syn. *F. acuminau* (Woot.) Cockerell

(Apache plume!

SW, USA. Mexico,

159. *Faruia athacea* Boiss.* (Hing)

E. Iran.

160. *Ferula assa-foe tida* L. (Hing)

India (Punjab, Kashmir), Iran, W, Afghanistan.

161. *Ferula foerida* Regel (Hingra)

S. Turkey, Iran, Afghanistan.

'About 60 species are widely distributed in C. Alia, Europe and N. Africa; in **addition to those listed, the N. African species *F. communis* L- and *F. tiogitana* L. (syn. *F. sanctB* Boiss.) are of minor commercial importance as a source of 'ammoniac of Morocco' (used medicinally I and various other species, e.g. *F . narthex* Boiss. and *F.persica* Willd., are sometimes used m Asia as a source of asafoeiida |jse entry no. 159).**

List of plants tolerant of arid or semi-arid - Part 45

Forage crop and 31 a shrub far controlling erosion [said to be excellent for this).

One of the principal sources of the gum-resin known as 'asafoetida', used medicinal I y las a carminative and expectorant) and as a flavour and condiment. It is Obtained a$ an exudate by slicing the upper part of the root and is marketed in three forms: teas, mass and paste.

A source of the gum-resin, asafoetida: *see* entry no. 159.

One of the principal sources of the gunvreiin asafoetida.

Seed contains: protein 30.6%; oil 36.8%. Hervre a possible oilseed.

Chief constituents of asafoetida are: resin, 40—64%; gum. 25%; essential oil, 10-17%; ash, 1.5—10%; plus traces of umbel liferone. Resin appears to consist of asaresinotannol both free and combined with ferulic acid. Gum it mainly a mixture of polysaccharides jD-galactose, Larabinose, L-r ham nose and glucuronic acid). The presence of two unidentified pineries, isobutyl propenyl disulphide (mainly responsible for the characteristic odourl, and various other disulphides has been reported.

***See* entry no. 159. This species has been suggested as a suitable crop for cultivation in the arid wastelands of Pakistan,**

Sfrft entry no. 159.

Commercial samples of asafoetida are frequently adulterated with cheaper gums, starch and cereal flours; very unpleasant to Take and **many medicinal alternatives.**

***See* entry no. 159.**

Chaudri, 1955 and references under entry no. 159

Sw entry no. 159

***See* entry no. 159.**

Benson and DartOUv, **1944 Deitschman ef *at.,* 1974 Jones and Barclay, 1972**

Arnon, 1972 Chopra *eral.,* 1960 CSIR India, 1956 Guenther, 1950 Jones and Thomas, 1961 Kazmi, 1951 Martindale, 1977 Raghavan *et al.,* 1974 Shivashankar er *al.,* 1972 162. *Ferula yalbaHiftua* Boise. & **Buhse.**[1']

IGalbanum)

Iran

163. *Ferula svawotens* Aitch & Hemsl.

(Muskroot)

C. Asia.

164. *Fviuta sunibuf* (Kauf (m.) Hook. f.

(Muskrcot)

C. Asia.

165 *Fouquieria sp/endens* E ngeI m.

(Ocotillo, ocote, candlewood shrub, coachwhip, devil's walking slick)

SW. USA (particularly the Sonora

desert); Mexico.

[f] *F. Ceratophylia* Ftegel Si Schmalhausen, from Turkestan, and *F. rubricaufis* Boiss, from N. Iran, are also sometimes used to a limited extent as a source of galbanum.

List of plants tolerant of arid or semi-arid - Part 46

Source of an oleo-gum resin, galbanum. used medicinally (as an expectorant I, as a flavouring, and also in perfumery, It is obtained, like asafoetida *Isee* entry no. 1 591, by incising the stem or root. Two types are available commercially - Levant, or soft, galbanurn, and Persian, or hard, galbanum. Reported to be of some importance in the French perfumery industry.

Dried root? used medicinally by, and to some extent as, a source of an essential oil Coil of sumbul').

As for previous entry, the two species being used interchangeably.

Wax resin from stems reported TO BE used for a belt dressing and earlier for rubber. Plant extract used medicinally by Apache Indians. Stems used for fencing and construction,

Flowers are edible.

Gum resin composition typically: resin, 50-70%; gum, 20%; essential oils, 25%; ash, up to 3%; moisture, 1 —10%. Resin consists of umbelliferone (free and combined), galbanic acid (acoumarin carboxylic acid) and two isomeric lactones. D-a-pinene, 0-pinene (ca. 55%), myrcene, cadinene, camphene, 0-ocimene, 3-carene and Cf-carene and Cf-cadinol reported in the essential Oil, plus a group of eight pyrazines, including 2-methoxy-3-sec-butyl pyrazine K 0,05%) found to be responsible for the oil's characteristic aromatic odour. Fruit also contains 2,35% of an essential oil, approximate composition D-^-pinene, 30%; DL-ft- and D-Q-pinenes, 40%, D-limonene, 1.5%.

Root contains 9% of a gum resin and 0.2-1.37% of an essential oil with a musk-like odour (and so could have applications for many perfumes).

As for previous entry.

A triterpene, ocolillo! (CjoHs^O^), rn.p, 198-?00°C, and with an unusual Icyclic ether) side-cham structure, has been isolated from the waxy resin; also two new triterpenes, fouquierol and isofouquierol.

Rarely used medicinally nowadays (except locally).

Despite its apparently desirable odour, the oil has never attained commercial importance (possibly because the musk odour is only 'faint').

As for previous entry.

Arnon, 1972 Borisov *et at.,* 1973 Br am we 11 *et St.,* 1969 Burrell et *a!.,* 1970 Chr^tien-Bessiire er *al.,* 1967 CSIR India, 1956 Guenther, 1950 Martindale, 1977 Naves, 1967 Naves, 1969

Shivashankar *et al.,* 1972 Teisseire, 1966

CSIR India, 1956 Guenther, 1950 Shivashankar *et al.,* 1972

See previous entry

Anon, 1916

Benson and Darrow, 1944 Burgess, 1966

Butruille and Dominguez, 1974 Hal Is and Wsrnhoff, 1963 Krochmal *et a!.,* 1954 Warnhoff and Halls, 1965

166, *Garcia nutans* Rohr (Pinoci(lo)

Mexico, Venezuela,

167. *Gtycyrrhiza glabra* L*

I Liquorice, licorice)

Mediterranean, Asia Minor; has Seen introduced successfully into SE. Asian sub-continent.

168. *Grindelia squarrosa* IPursh) Dunat

{Curly cup gum weed, resin weed, tarwaad)

Western N. America from Saskatchewan to Mexico, particularly along dry river beds.

*** There are several sub-species, of which the most xerophile is *G. glabra* var. *violacea* Boiss., Persian liquorice.**

List of plants tolerant of arid or semi-arid - Part 47

Extract of dried roots widely used in medicine, particularly as an expectorant. Also used as a flavouring, especially for tobacco in the USA, as a sweetener and in confectionery. More recently used as a source of glycyrrhetfinlic acid used in the treatment of Addison's disease and in the preparation of antiinflammatory agents for the treatment of gastric ulcers. Chief producers of fiquorice root are: Spain, France, Greece, Italy, Iran, Iraq, Turkey, Lebanon, Israel and USSR. Principal producers of solid extract are: USA, France, Italy, Turkey and Israel.

Decoction of flowers and leaves at One **lime used as an anti-spasmodic** and **stomachic.**

Seed contains about 41% oil, kernel, 53-56%. Oil has sap. val., 189.2-192.4; iod. val., 176,8-177.8;acid val, 1.1; fatty acid composition: elaeostearic (conjugd triene; Cj_B), 35-91%; oleic, about 10%; trace linoleic. Hence a possible drying oil (similar to tung oil) and investigated as such during 1940s.

Principal constituents of roots: glycyrrhizin, 2—14%; glucose, up to 3,8%; sucrose, 2.4—6-5%; starch, 30% asparagine, 2—4%; essential oil, 0.03—0.35%.

Glycyrrhizin is the potassium salt of *a* triterpenoid saponin, giycyrrhinic acid, the parent aglycone of which isglycyrrhetieacid. In addition, several minor constituents have recently been identified — including various other (related) triterpenas, various flavonoids (fievores such as formononetin, liquiritigenin, liquiritin; isoflavones such as glyzarin; and two chalcones) and a coumarin, licftoumarin. Tc what, if any, extent these substances

contribute to the medicinal effect of crude root extracts is unknown. Spent pulp left after extraction can be utilised for the production of a foam stabiliser, foaming agents, alcohol, insulation boards, etc.

Contains a sterol glucoside ('grindelol')[1] and an alkaloid, grindeline; 9lso many diterpenes and flavonoids. Seeds contain protein, 14%; oil, 20% (with iod. val., 138, sap. val., 18G). A possible oilseed.

At the time of the investigations in 1940s, natural supplies were estimated at less than 10 tonnes p.a, and experimental plantings were made in the USA to assess its usefulness but there has apparently been no follow-up.

Demand is mainly for extract and is fairly static. Establishment of extraction plants involves a relatively high capital outlay. The plant is not a complete xerophyte (but Drar considered that it would be valuable to study it under desert conditions). Value in ulcer treatment disputed.

It has been suggested that there needs to be a revaluation of the chemotherapeutic properties of *Grindelia* Spp,

Cruse, 1949

Gardner and Westgate, 1943 Lundell, 1945 Lynch, 1944

Madrazo and Sierra, 1964 Westgate, 1944

Bhardwaj *et al.,* 1976a

Bhardwaj *et* a/., 1976b

Bhardwaj era/., 1977

Chopra *eta!.,* I960

CSIR India, 1956

Drar, 1955

Elgamal *ai,,* 1965

Elgamal *eta),,* 1972

Elgamal era/., 1975

Hulls *et a!.,* 1971

International Trade Centre, 1974

Isenberg, 1956

Larkworthy er *o!.,* 1977

Masters, 1972

Paris and Dillemann, i960

Saitoh and Shibata, 1975

Ayensu, 1979 Cheney, 1962 Earle *et ah,* 1960b Krochmal *eta!.,* 1954 Krochmal and Krochmal, 1973

169. *Gynnndropsis gynandra* IL.) Br q ; syn. O' *perttapiiy/la* DC (Cat's whiskers)

Tropics generally Especially india, S. China and W. Africa).

***}* 70, *Gypsophila rokejeka* Defile (White or Levantinian soap root) Middle East.**

171. *Haloxylon* spp.

ISaksaul, saxaul (for various tree species), ghada tree)

Mediterranean region, USSR, Algeria, Syria, Afghanistan, Iran.

Seeds used as an anthelmintic. Leaves used as a pot-herb and for flavouring and in traditional medicine.

Used in the preparation of halave (a confection typically made from sesame seeds and honey].

Trees and shrubs in desert regions whose timber is used as a fuel.* In addition *H. schweinfurthit* Aschers. ex Aschers. & Schweinf., is source of *a* manna, and the gum is consumed by Bedouins: the wood is used for carpentry, and the tree planted as a sand-binder. Ash of *H. ammodendron* Bunge is used in Kazakstan for control of mange in sheep; and *H, penicum* Bunge ex Boiss & Buhse provides camel fodder and grows in areas with 25 mm

11 in.) rainfall annually.

Seeds contain *J* 7—22% of a greenish oil, with faint mustard odour. Sap. val., 194: iod. val., 114—122; unsap. matter, 2—3.5%. Approx. fatty acid content (pfe-g.l.c.): linoleic, 54%; linolenic, 2%; oleic, 15%; palmitic, T8%; stearic, 8%; arachidic, 2%; rrtyristic, trace, A possible Oilseed: in particular the oil considered to have potential for soap manufacture. 0-D-giucoside of ^-sitosterol and free fj-sitosterol (triterpene), hexacosanol (a wax alcohol, $C_{26}H_{54}O$) and kaempferol (a flavone; $Ci_5H_{10}Cl_6$) also isolated from the seeds. An unsaturated lactone (^C^H^C^I, said to be cause of medicinal activity, reported early or but not confirmed on reinvestigation.

Plant contains up to 16% saponins. Suggested worth investigation as a source of sapogenins (precursors of steroidal drugs).

Anabasine (a nicotine-like compound) found as the major alkaloid in *H. persicum* and nicotine the minor alkaloid (both powerful insect poisons) Total alkaloid content, 5.4% on dry basis. Eight alkaloids, including halosine of known (Cjq) structure, have been found in *H. salicor-nicum* Bunge ex Boiss. *H. aphyUum* (Mmkw.J lljon can provide both cattle fodder and fuel; and desert reclamation/cultural experiments are being conducted in the USSR, Haloxylon wood is equal to coal in calorific value and is already used as a basic fuel of the desert people in C. Asia.

Collection of seeds (for oil) said to be a problem, High acid value of stored oil sample may indicate a strong lipolytic factor in the seed. Plant, which is an annual, reported to be poisonous to poultry and sheep in Australia. Bruised leaves tend to be vesicant.

Present-day market for steroidal sapogenins is indifferent.

***H. ammodendron* only grows very slowly and the wood is extremely hard. The alkaloids are of little medicinal value. Anabasine and nicotine avoided nowadays wherever alternatives are available.**

CSIR India, 1956 Gupta»rd/.. 1968 Sen Gupta and Chakrabarty, 1957

Sen Gupta and Chakrabarty, 1964a Uphof, 1968

Copper, 1980 Zaitschek, 1953

Babayev, 1978 Habib era/., 1974 Lagereva, 1947 Linnard, 1960 Michel era/,, 1969 Paris and DiHeimann, 1960 Riviere, 1931 Sandberg *eta!.,* 1960 Uphof, 1968 Zohary, 1940a. b

' *H. aphylium* and *H. persicum* considered potential firewood species by the National Academy of Sciences, 1980.

List of plants tolerant of arid or semi-arid - Part 48

Current/past use?

Citation data

\ *72. Haocornit specwsa* Gome* (Mangabeira, mangaha)

NE. Brazil.

173. *Haptophyton cimictdtum* A.DC*

(Cockroach plant)

Mexico from Guaymas, Sonora southeastward, and Guatemala,

174, *Hetiopsis tongipes* (A. Gray) S. *f.* Blake

(Chilcuague, chilcuan]

Mexico.

175. *Hyosnyamus aibut* L.

(White henbane!

Grows wild in Mediterranean countries, particularly Egypt.

Was exploited commercially for rubber in early 1900s and during World War II, and even now used locally as a source Of second-cless rubber; fruits used for juices, sherberts and ice cream.

Traditionally used to poison cockroaches, lice, flies, etc.

Extract of roots employed in the preparation of insecticides for local use.

Drug plant; source of the alkaloid hyoscyamine tee entry no. 1761.

Rubber content Of latex, 26—40%: high in resins (10—13%),

Contain; a series of indole alkaloids mainly of the eburnamina and aspidospermine 15 and 6-rings respectively) types such as: haplophytine IC$_3$7H4.$_0$N*07i uptaO.03%), cinnicidine (C23H2BN2O5), haploeine (022^28^2^3), hap loci dine (C^iH^NjOj), and cimicine ICjpgHgeNzOij)-Some are structurally similar to the anti-tumour vinca alkaloids and so may have interesting pharmacological activity. Potential insecticide; effective against froit-flies.

Roots contain about 1% of an amide, l\t-isobutyl-2, 6, 8-decatrie noamide, which has a similar paralysing action and toxicity to houseflies as the pyrethrins. Originally, sample examined by USDA was designated *Erigeron aftinis* DC and considered to be a promising natural insecticide.

All plant parts contain alkaloids, principally hyoscyamine plus some hyqscine. Alkaloid content varies: roots,

0,1-"0.3%; leaves, 0.06—0.56%; stems, 0-07-0.13%; flowers 0.13%; fruits, 0.06%; seeds, 0.04%. The plant is used in some countries as a substitute for the official drug henbane, yee entry no. 176.

Low yields of latex, often trees can be tapped only once a year. Soft rubber deteriorates on storage; need to improve processing.

Insecticidal activity varies, probably according to growing conditions. Cheap production would be necessary to compete against synthetics.

Distribution restricted: cultivation would **be** necessary **to** supply commercial Quantities.

Similar constraints to those noted under entry no. 176: competition from synthetic substitutes and from other natural sources. Also low (? and erratic) alkaloid content.

Mors and Riz?ini, 1966 Pol ham us, 1962 Santa Rosa, 1960 Schery, 1949

Benson and Darrow, 1944 Caldwell, 1966 Cava *et al.,* 1963a, b Plummer, 1938 Roark, 1947 Rogers * *tat.,* 1962 Snyder *era!.,* 1954a, b Yates *etsl.,* 1973

Acree *et* a/., 1945a, b Jacobson *et al.,* 1947 **Little,** 194a **McGovran ef *a!.,* t947 Roark 1947**

Chopra *et a!.,* 1960 Khafagv era/., 1965

' A closely related species *H. crooksii* L. Senson, the Arizona cockroach plant (found in the desert areas of Arizona, New Mexico, Texas and Mexico) has been suggested Ssan effective insecticide, but does not appear to have been investigated.

List of plants tolerant of arid or semi-arid - Part 49

No mu {if;[1] Distribution

Current/fiast uses

Cits:ion data

176. *Hyoscyarrti/s muticus* L.

(Egyptian henbane)

Indigenous 10 Egyp!, but nouv extends easi wards to Pakistan ! Punjab and Smci).

17 7. *Hypftaei*it *rhebaica* (L.) Mart

(Egyptian doum patm, ginger bread palm \

Native of Egypt, bjt widely d'Stribuled iri more arid pans of 1AT and

E. Africa; also found in EE. Asian sub- continent.

Drug plant; commercial source of the alkaloids hyoseyamine and hyoscine these being, respectively, an optical isomer of atropine with similar, and

important, pharmacological activity and its epoxide cler,uative. Both are used widely in various medicinal preparations — as 'calming' agents in, for example, travel sickness pills, in eye ointments etc.

Fruit kernel formerly utilised os a source of vegeiable ivory, used for the manufacture of buttons. Now used in local crafts. Fruit and roots used in indigenous medicine. Leaf and root fibre used locally for ropes; leaf also used for thatching, baskets, etc. Fruits and immature kernels are also used for various edible products. Timber used for construction.

Commercial samples normally contain 0.6-1% total alkaloids, of which 90% is hyoscynminn, Alkaloid content highest in leaves, up to 1.4%: (seed, 0.9-1.3%: stems, 0.6%1. I n the Negev desert plants with a total al ka I oid content of 2,5% have been obtained expen mentally. Other constituents are hyoscine, traces of atropine and tetramethyl-tJiamino-butane. The seeds also have medical properties but are rarely used — the dried leaves (and flowersl normally being the pans used for drug preparations.

Kernel contains 6- 10% of an edible oil; sap, val.,

225-249; iod. val., 28—33; unsap, matter 1.9%; f.f.a. content, 1,3-1 ,6%; fatty acid composition: caprylic,

0.7-1,3%; capric, 2.8—7.0%: lauric, 31.8—38,4%; myristic. 14.8-19.9%; palmitic, 7,1 —1 3.8%; stearic, 1.4—4,8% fCg— Ci s saturated acidsl; and oleic, 24,8%; linoleic, 0-7%. Fibre properties: wt. per unit length (ten), 10.4; breaking stress [grtex), 35; extension to break, 4.3%. Length of ultimate fibres, 1.7—1,9 mm, diameter, 13 jum; cell wall thickness, 4.5 fim. Possible source of paper pulp.

At one time wild plants in Egyptian deserts were exploited on such a large scale that natural supplies mere endangered. Attempts to cultivate have not been very successful and have been handicapped by declining demand, partly because of synthetic substitutes and the availability of other natural products: eg the closely related species *H. niger* L. and DufroWf'aspp. (iee entry no. 113). In addition cultivated plants were found to have a lower alkaloid content that those growing wild (though aridity reported to increase alkaloid content). Was (? and still is) considered to be a promising crop for the Negev and arid areas of Pakistan and India; however experimental plantings in India yielded plant material with a low alkaloid content.

Oil content too low for exploitation as an oilseed. Now only used to a very limited extent for the manufacture of speciality buttons and craft articles. Although good quality paper is obtained from the leaf pulp, yield is poor. Wood gives inferior quality pulp. Extraction of the fibre is difficult and laborious and there is a need to develop more efficient decortication methods. Has been suggested as a useful tree for the Sahara but requires under-

Ahmed and Fahmy, 1951 Chaudhri and Saleem, 196? Chopra *et at.,* 1956 Chopra *et at.,* 1960 CSIR India, 1959 Drar. 1954

Duisberg and Hay, 1971 Evenan *et* a/., 1971 Martindale, 1977 M ifal and Saxena, 1977 Paris and Dillemann, 1960 Saber and Balbaa, 1954 Zaitschek, 1953

Coursey, 1**964** CSIR India, **1959** Drar, **1954** Giffard, **1966** Laws and Jarman, **1962** Osborn, **1950**

Rajagopal and Achaya, **1961**

ground water near the surface.

List of plants tolerant of arid or semi-arid - Part 50

17S. *Hyssopus officinalis* L, (Hyssop)

Native of Mediterranean region and temperate Asia; has beer naturalised in the USA.

Source of an essential oil used medicinally, for perfumery, and as a flavouring (particularly for liqueurs).

Yield of essential oil from dried leaves and flowering tops about 0.8%. About 50% of this ('hyssop'} oil consists of the (CjqI pinane derivative L-pinoeeimphone; other compounds present include ct-and^-pitienes, Ipinocampheol, and a series of minor mono- and sesquiterpenes. Seeds contain: protein, 27%: oil, 29,4% and hence a possible oilseed crop. Has beer recommended as an anti-erosion crop, particularly in semi-arid mountainous regions.

The essential oil is relatively expensive and is sometimes adulterated with lavender or rosemary oils. Possible climatic constraints *isee* 'Distribution').

CSIR India, 1959 Guenther, 1949 Jonas and Barclay, 1972 Joulain and Rageult, 1976 Katz, 1950

Paris and Dillemann, 1960 Sharms er af., 1963 Tucgkov, I960

179, ***Isomeris arborea*** Nutt.

(Burro fat)

SW. USA.

1 SO. *Jatropha csrdiopbylls* (Torr.l Muell. Art},

(Limber bush)

SW. USA (Arizona, Sonora desert), Mexico.

181. *Jatripha cinerea* (Ortega) Muell. Arg.

(Lcrnboi, **ashy** jatropha)

SW. USA (Sonora desert), Mexico.

182. *Jatropha Cuneata* **Wiggins** & **Rollins;**

syn. *J. spathulata* (Ortega) Muell. Arg.

(San<jre de drago)

SW. USA, Mexico.

Reddish root juice, at one time used as a tanning materiel or a dye. Said to be used medicinally in Mexico.

Said to be used medicinally in Mexico.

Stems used for making baskets and whips. Bark used for tanning and as a source of red dye. Used medicinally in Mexico.

Seeds contain: 37--40.6% protein; 42— 45% oil; sap. val., 189: iod. val,, 107. Hence possible oilseed?

Roots contain over 5% tarnic acid on a dry basis. Stems are reported to contain 3% rubber.

Seeds contain: protein 28.1%; oil, 50.9%. Oil has sap. val., 188; iod. val., 105; fatty acid composition: linoieic, 6,3%; oleic, 65.2%;saturated*. 15%, Possible oilseed.

Presence of alkaloids reported (? possible medicinal value).

No/iott-food uses actually recorded (in references available).

Benson and Darrow, 1944 Earle et *at.,* 1960b Jones and Barclay, 1972

Benson and Darrow, 1944 Hall and Long, 1921

Bachstez and Ripoll Gomez, 1954 Benson and Darrow, 1944 Reis Altschul, 1973

Benson and Darrow, 1944 Dominguez *et»!-,* 1960 Uphof, 1968

List of plants tolerant of arid or semi-arid - Part 51

Potential Constraints

1 S3. *Jatropha* ciyfMS L,

(Physic nut, purging nut, pig nut, Barbados nut)

Shrub which is very widely distributed throughout the tropics (grown commercially in the Cape Verde Islands and in Madagascar).

184. *Jatropha macrorhira* Benth. Ari?onj Mexico.

185. *Jatropha phyllacafttha* Muell Arg.;

syn, *Cnidoscolus phyllacanthus* Muell.-Arg. Pa* & Hoffm.

(Favela, favele'aj

NE. B^{r}aiil.

Used medicinally (purgative! in many parts of the tropics. Source Ol a semi.drying oil, used for a variety of purposes, e.g. soap manufacture, med-icinaFly, as an illurmnant, textile lubricant and* after chlorination, aiS plasticiser. Detoxified oil cake has been used as a protein nutrient source in production of antibiotics by microbial fermentation, Oilcake also used tor production of synthetic fibres.

Used bythe Mexicans as a purgative,

Source of edible oil, suitable for use as a salad oil and for soap manufacture. OiIcake suitable for animal feeding and for enriching cassava flour, Bark and roots used for animal feed in trnoes of drought. Wood used for fuel.

Kernel forms 60 80% of seed weight arid yields about 18% protein, 46-60% oil. Oil has sap. val., 138- -196; iod. val., 93-107; unsap , matter 0.4—1.1 %; fatty acid composition: oleic, 37—63%; li noleic, 19-- 40%; palmitic, 12-1 7%; stearic, 5~ 6%; arachidic, 0.3%; myrist ic, 0.5%, Suggested use is as a motor oil in diesel engines (and if purified and refined, for edible purposes? l/j-D-glucoside of ^-sitosterol hss been isolated from the seed, stem and bark. 0-amyrin, taraxerol and/i-sitostero! Itriterpenes) present in stem bark. Leaves contain stigmasterol,j3-sitosterol, and another triterpene alcohol. Plant also exudes an acrid latex containing 14.6% resin. The bark also contains tannins (37% dry basis), *o* wax la mixture of 'melissy!' (myristyl Cj^l alcohol and myristyl myristate), and a dar k blue dye. Has been suggested as a su itable crop for the arid and semi-arid aress of NE. Brazil, not only as a oilseed, but also as an

anti-erosion and soil improving crop. I n some areas the seed is used to adulterate castor seeds. An alcohol extract of the aerial parts shows anti-tumour activity.

Plant root extract found to have tumour-inhibitory action and recently two anti-tumour agents have been isolated: jatropham (B-hydroxy-4-methyl-3-pyrrolin-2-one) and a diterpene, jatrophatrione (C^oHjgOj).

Seeds contain about 25% protein; 30-37% light yellow edible oil, sap. val., 195; iod, val., 109; saturated fatty acids, 27%, unsaturated, 72%. Residual oilcake has a protein content of about 26%, Exudes a latex which contains a combustible resin.

The seeds (and the crude oil) contain a toxic principle, curcasine, which produces skin lesions on mice — and so may present handling problems; and the latex is said to be 'acrid'.

Shrub covered with large prickles exuding an irritant juice, which can cause harvesting problems. At orte time considered to have a potential as an industrial crop in NE. Brazil but handicapped by harvesting problems (but the potential could be improved by exploiting a recently claimed non-spiny' variety).

Coursey, 1964

CSIR India, 19S9

El K.ey *et al.,* 1966a

Godin and Spensley, 1971

Hufford and Oguntimein, 1978

Khafagy *et al.,* 1977

Mensicr and Loury, 1950

Mitra ef *at.,* 1970

Santa Rosa, 1949

Santa Rosa, 1960

Slirpe et *St.*. 1975

Vyas and Desai, 1952

Williams, 1966

Reis Altschul, 1973 Torrance ef *at.,* 1976 Torrance *et &),,* 1977 Wiedhopf *etal.,* 1973

De Parcevaux and AHirand, 1977 Dodsworth Machado *et at,,* 1950 Mors and Rizzini, 1966 Santa Rosa, 1949 Santa Rosa, 1959 **Santa Rosa,** 1960

List of plants tolerant of arid or semi-arid - Part 52

Sirriilar remarks apply to *J. rrgidus* Desf. — which on balance appears from the 1979 reports to be preferable 10 *J. dcutus.*

List of plants tolerant of arid or semi-arid - Part 53

Name(s)/Distribution	Current/past uses	Potential	Constraints	Citation data
186. *Juncus acutus* L.* Europe, Mediterranean, Israel, on the sandy dunes of the coastal plain.		A tussocky, low rush. Approximate composition of stems (oven-dry material): cellulose, 47.3%; pentosans (possible raw material for furans and allied chemicals), 22.4%; lignin, 20.0%; ash, 5.4%. Fibres are fine with an average length of 1.11 mm. Seeds contain an oil (? edible) and are rich in organic acids, sugars and amino acids. Considered to be a potential papermaking material in Israel. Pulp would be suitable for writing paper (grade index 75%). Plant is very suitable for stabilization and fixing of sand dunes and absorbs salt from brackish soils.	Adequate growth may require N/P (fertiliser) supplementation; oil not yet tested for toxicity.	Lewin, 1953 Zahran *et al.,* 1979
187. *Juncus maritimus* Lam. N. Central Africa and SE. Asian sub continent areas where there is brackish underground water.		Approximate composition of stems (oven-dry material): cellulose, 48.0%; pentosans, 23.7%; lignin, 18.65%; ash, 6.65%. Average fibre length, 1.46 mm; width, 12μm. Experimentally, a yield of 34—39% bleached pulp obtained, intermediate between esparto and straw pulps. Considered to be a potential source of paper pulp in Israel. Attempts made to develop cultivation in the Negev; is particularly suitable for saline soils.		Bloch *et al.,* 1954 Evenari and Koller, 1956 Lewin, 1953

* Similar remarks apply to *J. rigidus* Desf. – which on balance appears from the 1979 reports to be preferable to *J. acutus.*

Potential Constraints

1B8. *Larrea divaricata* Cav." (Creosote bush, jarillal In the Gran Chaco desert of Argentina (and also in similar areas of Chile, Bolivia, Peru).

Leaves and twigs have a resinous coating from which nordihydroguaiaretic acid INDGA), a phenolic I ignan (i.e. substituted dibenzyl-ethane) used as an antioxidant in foods, cosmetics and pharmaceuticals, may be extracted. Plant extracts used in indigenous medicine in Mexico; found to have antimicrobial and tumour-inhibiting properties,

Dried leaves contain 14.0% crude protein;18% ether extract (fats); 44% 'N-free extract[1] (mainly carbohydrates); 16—21% total phenolics (NDGA content, 8—9%); in addition the related lignans dihydroguaiaretic acid, norisoguaiacin (and its 3'-demethoxy derivative! have been isolated; and these compounds have anti-tumour activity. Leaves high in protein and could be used for production of animal feed. Possibility of integral utilisation of *Latrea* spp. investigated in Argentina. *See* also footnote[1]

Bender. 1963 Blaizot and Cuvier, 1949 □ uisberg, 1952a, b, c Duisberg and Hay, 1971 Gisvold and Thaker, 1974 Grice *ex at.,* 1968 Horn and Gisvold, 1945 Krochmal *eta!.,* 1954 Mabry et *al.,* 1977 Mizrahi, 1967 Oliveto, 1972 Paris and Dillemann, 1960 Parker, 1980 Waller and Gisvold, 194S

From 1943 for about 25 years, utilised as a commercial source of NDGA (used as an antiOxidant) but recently an improved synthetic method has beer developed for the production of NDGA so that the future for the natural product is less promising. Also the use of NDGA in general, at least in foods, has recently been curtailed following toxicity studies which have led to its removal from the US Food and Drug Adminstration's GRAS ('generally recognised as safe') list similar restrictions also apply in the EC. Commercial utilisation of the shrub for the product ion of an animal feedingstuff considered not economic, unless other products (e.g. NDGA or resins) are also obtained.

189. *Larrea tndnntata* (SesstfA Moc. ex DC.) Colville[1]

(Creosote bush, hediondilla, hideonado) SW, USA, N. Mexico.

The most common desert shrub in SW. USA. Utilised as source of NDGA *as per* the previous entry, and as a source of resin for varnish manufacture in 1940s.

Fresh, machine-threshed leaves reported to have a NDGA content of 1.31 — 1.84%. Also contain 0,54% of a dark-orange hard wax, m.p. 73.5^{j} C. Fungicides can be made from the phenols (lignans) present in resin; and resin itself is fungistatic (fungicidal at high concentrations) and is also amoeblcidal. Residual plant material could he used as fodder or for other conventional cellulose use. Subject of recent 11978) international conference

at Centro de Investigacidn Quimica Aplicada (CIQA), SalthiUo, Mexico ('Larrea: a vast resource of the American deserts') and a book I Mabry ef *al.*). See also footnote[11].

***See* previous entry. The 1979 authors note that it is 'a very aggressive shrub' which can be 'a major pest' since it invades, and Overwhelms, any adjoining grassland; and that NDGA shows toxic effects.**

Cruse. 1949 Fernandez *etal.,* 1979 Kurtz, 1958 Mabry *al,,* 1977 Page, 1955

Paris and Dilleman, 1960 Tipton and McWilliams, 1979

*** In addition, in the Gran Chaco desert *L. divaricata* forms associations with *I. cunei folia* Cav. and *L. nit ids* Cav,**

[T] *L. divaricate* and t- *tridentata* are very closely related; in fact, some authorities do not consider that there are two distinct species while others (see e.g. Lloyd 1979) consider the N. American creosote bush to be solely *L. tridentata* and the other *Larrea* species to be restricted to S. America. The comments are allocated to *L. divaricata* and *L. tridentaxa* as by the original authors, but can probably be combined. The leaves of all *Larrea* species contain, in addition to N DG A and its derivatives, a series (Mabry ef *a!.,* 1977) of flavonoid glycosides, terpenes (a-pinene, camphor, *etc.*), paraff inic hydrocarbons land derived ketones), wax esters, and triterpene glycosides — some of which may be of use (? or could be used *in toto* as a fuel I.

List of plants tolerant of arid or semi-arid - Part 54

190. *Leptadenia pyrotechnics* (Forssk.) Decne. syn. *L. ipgrtium* Wight

(Markh)

Africa — particularly N. Nigeria, Sudan, Egypt and Mauritania;

SE. Asian sub-continent.

191. *Lesquere/la fenderli* (A. Gray I S. Wats.*

(Fendler biadder pod)

Indigenous to SW. USA and **N. Mexico.**

Utilised for fodder and thatching; roots are sometimes eaten as *a* vegetable.

Plant has been suggested as being worth further investigation, e.g. as a possible source of fibre for rope and as 9 pgpermaking material.

Seeds contain: protein, 20.6—22.5%; oil, 19.8—28. t%.

Oil has iod. val., 105—108and contains 57% lesquerolic acid (14-hydroxy l 1-c/i-eicosanoic (C20^ acid). Oilcake contain; 34% protein, high in lysine. Hence considered to have potential as an industrial oilseed, simitar to castor, and giving a versatile industrial oil rich in hydroxyacids and also a nutritious oilcake suitable for animal feed. Occurs as a winter annual in semi-arid areas of the USA and has received considerable R and □ . Has been grown experimentally in Israel. A polymorphic species so selection could provide a high-yielding plant adapted to mechanical harvesting.

Fibre reported to be difficult to extract,

In Israeli experiments, germination rate was low (but plarrt breeding may help). Inactivation of lipolytic enzymes essential during extraction to obtain an oil with low f.f.a. content.

Drar, 1954 CSIR India, 1962

Barclay **t et*., 1962 Duisberg and Hay, 1971 Gentry and Barclay, 1962 Knowles *«t $1.,* 1964 Mikolsiciak ef a/., 1962 Miller *eta!.,* 1962 Princen, 1979 Pringen, 1982 Sharir and Gelmond, 1971

*** About 72 species are found growing wild as spring annuals or perennials in SW, USA and Mexico, with seeds containing 11—39% oil with a hydroxy acid content of 45—74%; and of these *L. fenderti* appears to be a species with potential as an annual, cool semi-arid, industrial oilseed crop.**

List of plants tolerant of arid or semi-arid - Part 55

Current/past uses

Citation data

192. *Leueaena leucpcephata* (Lam.) 1 Leucaena, ipil-ipil, horse tamarind, lead treel

Native to Mexico, but now widely distributed throughout the tropics.

A very quick-growing leguminous tree. Utilised mainly for forage, but wood can be used for fuel or making charcoal and for paper pulp, fibreboard etc. Pods and seeds sometimes used a$ a -foodstuff. Seeds used for decorative purposes in craft work. Various parts of plant used in indigenous medicine, and as a source of dye. Atso grown as an ami-erosion crop, ornamentally and for soil improvement, etc. Leave; provide a good green manure.

Protein content of foliage of high nutritional quality: am mo-acids present in well-balanced proportions, similar to alfalfa. Considered to have potential as a versatile legume crop for non-acid soils in semi-arid and savannah areas. The leaves also have a high carotertoid content and can replace alfalfa or synthetic cartenoids in poultry ■feeds (to colour the egg yolks) although antioxidant mav need to be added for prolonged storage. Wood is high in holocellulose (72%); pulp yield, 50—52% (comparable to other fast-growing hardwoods}. Fibres have average length, 1.2D mm; diameter, 0.025 mm. Seeds contain 25% of a water-soluble gum (similar to gum arabic, guar, or carob bean) and 9% oil and is a potentially usefut source of both. The oil has sap. val., 185; iod. val,, 110; unsap. matter, 4.7%; fatty acid composition: linoleic, 54.3%; oleic, 23,6%; palmitic, 12.7%; stearic, 5,0%; behenic 3.6%; lignoceric *iC^4* saturated!, 0.7%.

Leucaena wood ha; high calorific value and its charcoal has 70% heating value of fuel oil. Coupled with high growth rate, should make good source of firewood, Philippines considering growing it in plantations as an energy source: 1 m barrels oil equivalent from 12,000 ha p.a.

List of

Excessive amounts of pods/ seeds or leaves in the diet, or forage (especially of nonruminants), results in ill health (goitre) due to the presence of *a* toxic amino-acid (mimosine: 3.5%, dry wt. basis, of the protein). Need for considerable R and D to develop improved (especially low-mimosine) strains. Also there is the complication of there being three types - Hawaii (bushy), Salvador (tall), Peru (much foliage) — with characteristics appropriate to different uses (firewood, energy plantations, and forage respectively); and the Hawaiian can become an aggressive weed difficult to control under ideal conditions. However all types show a tendency to grow vigorously only at below about 500 m (or 1,000 m near the equator). Needs a reasonably heavy soil; poor growth on sandy, stony or shallow soils. Seedlings prone to grasshopper and termite attack. Use as s building material hampered by the wood's tendency to insect attack. Plant failed to provide protection against, specifically, soil erosion in gullies (Malawi).

Its possible use as a commercial source of gum said to require further study.

plants tolerant of arid or semi-arid - Part 56

Anon, 1977c

Brewbaker and Hutton, 1979 CSIR India, 1962 FAO, 1976b

Farooq and Siddiqui, 1954 National Academy of Sciences, 1977a USAID, 1978 Vabes, 1977

Constraints

Current/past uses

Citation dat?

NameUMDisiribution

193. *Licanra rigida* Benth. (Oiticical

Indigenous to ME. Brazil.

A long-living (100 yrs) tree of up to 30 m high producing up to 2 tonnes pj. seed which yields a drying oil similar to tung oil (an excellent drying oil in considerable demand for the manufacture of paints, varnishes, etc.) and used in the production of paints, enamels, varnishes, plasticizers, linoleum, etc.: an *AZ* equivalent of (and substitute for) lung oil.

Seed consists of 60—75A6 kernel containing 55—63% of a viscous, semi-solid oil with various uses but an unpleasant flavour and odour. Exports from Brazil about 9,000 tonnes p.a. in early, 1960s. Sap val.,

186—195; iod. val., 139—185; unsap. matter 0.5—1 %; saturated fatty acids 10-11%; Oleic 4-6%; other unsaturated acids are mainly the Cib conjugated triene acids, QHicanic and an isomer of elaeostearic (coulpicic). Possibility of utilising oil-cake as a source of tannins or for the production of furfural has been investigated in Brazil; it contains 11.8% pentosans.

Supplies of the oil reported to be decreasing, partly because of variability o(yields and cost of labour required for harvesting from wild trees. Need to develop plantation production is recognised (and some research being done). Conservation measures have been taken in Brazil and export of seed has been prohibited to prevent introduction elsewhere.

Oil inferior to tung as regards colour (darker: can only be used for dark-coloured paints), drying rate and water resistance

— but giticica succeeds where tuog (which needs 750—1,000 mm p.a. rainfall) will not. Oilcake not suitable for animal feed because of its purgative action.

Francois, 1952 Godin and Spensley, 1971 Kehren, 1963 Markley, 1957 Mensier, 1957 Santa Rosa, 1949 Williams, 1966

194. *Umnanthes aiba* Hartw. ex Benth. (Meadowfoam)

A winter annual, native to coastal areas of N. California and S. Oregon.

Seeds contain: protein, 20%; oil, *71%.* The oil has iod. val., 94 and 95% of its fatty acids have more than 18 carbon atoms, major component acid 161 %) being cis-5-eicosenoic IC_2q) Could possibly be used as an industrial oil for the production of waxes, lubricants, detergents and plasticizers. Fully hydrogenated, a wax with a hardness approaching carnauba or candelilla is obtained. Genus considered to have potential for development as a source of an oil-wax similar to that obtained from jojoba. *L.niba* considered to be agronomically superior to other species and the most xerophytic; but all species have a mechanism of protective dormancy when temperatures are high.

All species require moisture, and soil temperatures of 16 C or less, for germination. Considerable R and D required on selection and breeding and also on utilisation of oil. Seeds contain (cf. rapeseed) thio-glucosidic precursors of volatile isothiocyanates and a small amount of an oxazolidinethione-like compound (2.7 mg/g in the resulting meal).

Brown ef *al.,* 1979 Devine and Johnson. 1978 Duisberg and Hay, 1971 Gentry ar*d Miller, 1965 Higgins ef *a/.,* 197T Miller era/., 1964 Toy and Willingham, 1966 White and Wolff, 1968

List of plants tolerant of arid or semi-arid - Part 57

195. *Loptiocereus schottii* (Engelm.) Britton ?nd Rose;

syn. *Cereus schotTii* Engelm.

ISemta cactus, cina, cabesa de viejo) S. Arizona^N. Mexico (especially Sonora des&rt) arvd Baja California.

196. *Lygeum spartum* ex. L. Loefl. (Albardine, esparto grass*)

N_ Africa (especially Tunisia},

S. Spain; also found in Mexico

197. *Lygos raetam* IForssk.)

Hey wood;

syn. *Retama raetam* (Forssk.) Webb & Benth,,

***Gentita raetam* Forssk.**

(R'tem, retem, retenshrub)

E. **Mediterranean (especially Sinai peninsula)**

Source of paper pulp suitable for manufacture of writing, wrapping and kraft papers. Can also be used for cordage and sacking.

A typical desert shrub; sheep eat small fruits. Wood is source of excellent charcoal (widely used by desert tribes); herb used as abortifacient, purgative and vermifuge.

Total alkaloid content of 3.7% reported, mainly concentrated in the green epidermis, Alkaloids pilocereine and piloceredine plus smaller quantities of lophocerine have been isolated. Hence a possible source of these (tetrahydroisoquinoline) alkaloids -which may be of value as anti-malaria! drugs. Five sterols also reported present.

Fibres; length, 1 3^4.5 mm; diameter, 0.010-0.027 mm. Composition: ash, 6—8%; lignin, 17—19%; pentosans,

27—32%; cellulose, 50—54%; a-cellulose, 33—38%.

Yield of screened pulp, 47.6-51 .6%. The paper has a high bulk capacity and dimensional stability toward moisture changes. A rapid continuous pulping process has been developed far the exploitation of the grass in Tunisia, Considered to have possibilities for development in Egypt.

The seeds contain 4,5% semi-drying oil Isap. val., 188; iod. val., 125) the unsaturated fatty acids being oleic, (47%), linoleic (27%}, and linolenic, (3%), plus 8% conjugated-diene acids. The saturated fatty acids (14%J include palmitic, stearic, arachidic, behenic and, probably, lignoceric acids. The *u*nsapomfiable fraction (4,5%), contains 75% ^-sitosterol. The mucilage from the defatted saeris contains (by acid hydrolysis),

19% 0-galactose and 78% D-manncse, Alkaloids in the seeds include therrnospine, d-sparteine, retannine, anagyrine, sophoramine and sophochrysine (all C15 tetracyclic compounds) and cytisine (Cji tricyclic).

Has been considered as a source of cellulose and fibre.

Cruse, 1959 Djerassi era/., 1953 □j era Hi *etah,* 1958 Kircher, 1969

Bergada Girona er *al.,* 1951 Clark, 1965

Cunningham era/., 1970 Drar, 1954

McGovern and Grant, 1962

Ahmed and Rirk, Boyko,1954 Uphof, 1968

1963

'More usually used for the grass *Stips tenacissfma* L. which is very similar; frequently no differentiation is made by the paper industry; see entry no, 265.

List of plants tolerant of arid or semi-arid - Part 58

Name(s)/Distributipn

Potential

19B. *ManihoT dicfioroma* Ulb (Manicoha de jequie; tequie manicobal Indigenous to NE. Brazil but not so widespread as *M. gtajiovii.* The species has been introduced successfully into Asia, notably India,and Hawaii.

199. *M^nihat glaziovii* Muell-Arg,

(Cegra or manicoba rubber)

Indigenous to NE. Brazil: has been introduced successfully into Africa, (notably Tanzania!, Asia and Hawaii.

200. *Manihot heptaphyila* Ule (San Francisco manicobal Indigenous to NE. Brazil.

201. *Manihot piauhiensis* Ule (Piauhy rubber)

Indigenous to NE. Brazil; has been introduced into India.

202. *Martyma parvi flora* Woot.t (Devil's claw)

Texas, New Mexico.

Source of good quality rubber. Hoots contain starch and are used as a foodstuff in times of famine.

Source of rubber. It is the most widely known and exploited of the rubber *Manihot* spp. and is reported to be resistant to prolonged drought, Seeds utilised to a limited extent in Brazil as a source of drying oil {manioc oil) used in paint and varnish manufacture and in the manufacture of dyes.

A minor source of rubber

Source of rubber.

Latex reported to have a rubber content of 25—50%. In Brazil, the latex is extracted by a series of zig-zag cuts and spontaneous coagulation occurs. The trees were exploited as a commercial source of rubber during the early 1900s and during World War II — and still considered to have this potential in Brazil. Seed kernels contain about 48% oil, which has sap. vaL, 187.7; acid val., 1.6; iod. val., 144*A:* unsap. matter 0,78% - and is a potential semi-drying oil.

Latex contains 3-12% resin. Analysis of coagulum: rubber, 92%; resin. 4.3%; insoluble material, 3.2%

Latex coagulates spontaneously; acid treatment of wound reported to delay coagulation and to increase latex flow. Vield in Brazil about 100 s latex per tree per tapping; in Tanzania about 220—330 g/tree/year. Is considered to have potential in Brazil. Seed kernel contains 25^45% oil which has sap. val. 188—193; iod. val ., 135-142; acid val. 0.6-1,7; unsap. matter 0.5-0 9%.

Roots are tapped for a latex similar to that obtained from *M. glaziovii.*

Latex obtained by lapping roots which is similar to that obtained from *M. glaziovii.* Seed kernels contain about 46% oil which has sap. val., 188; acid val., 1.6; iod. val., 144; unsap. matter, 0.78% - and is a potential semi-drying

oil.

Seeds contain: protein, 24%; oil, 35—36% — which has sap. val., 197; iod. val., 122. Seeds a possible source of oil, similar to cottonseed or sunflower seed oil.

Yield of latex rather low as compared with *Hevea.*

Burkhill, t935 CSIR India, 1962 Polhamus, 1962 Santa Rosa, 1949 Santa Rosa, 1960 Schery, 1949

Bor get. 1352 Burkhill, 1935 Coursey, 1964 CSIR India, 1962 Marsiand, n.d. Polhamus, 1962 Santa Rosa, 1949 Santa Rosa, 1960 Schery, 1949 Williams, 1966

Polhamus, 1962 Santa Rosa, 1960 Schery, 1949

CSIR India, 1962 Polhamus, 1962 Santa Rosa, I960 Schery, 1949

Duisberg, 1952a, b Krochmal *et at*.. 1954

Horny bark makes tapping difficult and resin content is rather high. Cannot be tapped continuously and, compared with *Hevea,* latex yield Is low.

'■/igrtality among trees is high and this species is now of minor importance in Brazil.

Mortality among trees is high and this species is now of minor importance in Brazil.

List of plants tolerant of arid or semi-arid - Part 59

*** See also entry no. 236**

Potential Constraints

203. *Moringa oteifera* Lam,; syn.

***M. ptsrygosperma* Gaertn. (Drumstick or horse radish treel**

Reported to be indigenous to India, but now widespread in many of the drier parts of the tropics, especially W. Africa and the Wl.

204. *Moringa pereg/ina* (Forssk.) f tori;

syn. *M. aptera* (Forssk.) Gaertn.,

***M. arabica* (Lam. I Pees (Egyptian ben-oil tree or ban tree}**

Egypt, Sudan, Ethiopia (Eritrea). Syria. S. Arabia.

305- *Mundulea sericea* (Willd.)

A. Chev.; syn. *M. suberosa* Benth,

Tropical Asia, especially SE, Asian sub-continent; Africa, especially Sahel and Sudan to Natal.

Source of light edible oil (ben or behenen oilJ used mainly as a lubricant (including, to a minor extent, commercially as a substitute for sperm whale

oil for lubricating fine machinery, e.g. watches). Also used in the preparation of cosmetics and perfumes.

Oilcake used as a fertilizer but unsuitable for animal feed due to presence of an alkaloid. Tender pods esteemed as a vegetable. All parts of the tree used in Indian indigenous medicine. Stem exudes a gum, used medicinally and in calico printing.

Source of a light edible oil used locally for cooVing, as a lubricant, and in the preparation of cosmetics and perfumes. Oilcake used as a fertilizer.

Seeds and bark used as a fish poison (grown for this purpose by farmers in the Sahel I and an insecticide. In India attempts have been made to isolate strains with a high insecticidal activity.

Seed composition varies according to origin.

Indian seed: shell, 23-30%; kernel, 70-74%. Kernel contains protein, 38.4%; otl, 34.7%; oil has sap. val,, 182.2; iod. val., 64,2;acid val., 3.5; unsap. matter,

3.05%; Fatty acid composition: palmitic, 9.3%; stearic, 7.4; behenic, 8.6; oleic, 65.7%. Oilcake contains 58.9% crude protein but has a bitter taste. Roots and bark contain 0,1 % alkaloids Imoringine and moringinine). Roots contain the alkaloid spirochine and also an antibiotic principle, pterygospermin (C22Hi$N202S2). Stem gum is a neutral polyuronide consisting of arabinose, galactose, glycuronic acid and traces of methylpentose. Analysis of wood: ash, 3.2%; pentosans, 1 7.6%; lignin,

26.4%; cellulose, 62,4%. Fibres average length, 1.14 mm, diameter, 28,um. Wood considered suitable for making paper pulp and of a grade suitable for the manufacture of writing and printing papers.

Seeds consists of 43% kernel which has an oil content of 52%. Oil has sap. val., 188.2; iod. val., 71.2; acid val.,0.5; unsap. matter, 0.5%; and is very similar to ben oil Iwe previous entry). Oilcake has a bitter flavour and contains: protein 48.6%; carbohydrate,

28%; fat, 2.6%; ash, 5.5%; fibre. 6.6%; plus saponins.

Hotenone la powerful contact insecticide and fish poison) content of E. African bark reported to vary from 0 to 1.1 %; elsewhere up to 2% (constituents vary greatly according to origin and strain). Indian bark samples reported to contain munetone (a substituted bis-dimethylchromene, CjgHjjOg)*, which is also highly toxic to fish, Indian and African samples also contain the closely related (+H2O) compound, mundulone*. Seeds contain gi$o an allied compound (C25H2406) which is toxic to fish. Alcoholic extracts of fruits and leaves reported to have antimicrobial activity.

Considerable scope for improvement and need for research on its medicinal uses.

Oilcake unsuitable for use as an animal feedingsiuff due to its bitterness.

Variability of nature and quantity of insecticidal constituents.

Bur khi II, 1935

Coursey. 1964

CSIR India, 1962

Guha *et at:* 1968

Guha and Negi, 1965

Ingle and Bhide, 1954

Ingle and Bhide, 1962

Kurup and Narasimha Rao 1950

Ranrvachandran *et aL,* 1980

Siddiqui and Khan. 1968

Subba Raosra/., 1953

Anon, 1930b Drar, 1954 Osborn, 1968

CSIR India, 1962

Dutta, 1955

Dutta, 1956

Dutta, 1959

Ghosh and Dutta, 1962

Narayanaand Rangaswami, 1955

Nickel I, 1959

Spickett 1955

Spoon, 1962

***For (revised) structures, see C. S. Barnes, J. L. Occolowiti, N. L. Dutta, P. M. Nair, P. S. Phadke and K. Venkataraman, *Tetrahedron Letters,* 1963(51, 281 - 288,**

List of plants tolerant of arid or semi-arid - Part 60

Name Is ^Distribution

206. *Nanophyton erinacajm* (Pallas) Bunge.

Asia.

207, *Neogtaziovia variegata* (Arr, Cam.) Mez

(Caroal NE. Brazil.

208- *Nicotians glauca* R. C. Grati

(Tree tobacco, masseyss)

Asia, Middle East, Argentine, SW, USA

209. *NoUna microcarps* S. Wats. (Bear grass)

SW, USA Mexico.

[For *Nopatea* sp., *see* entry no. 211]

Extract of the piperidine derivatives present is used, in the treatment of hypertension

Source of fibre, now used mainly for cordage, mats and braided articles.

Residue pulp reported to be uted for papermaking, and also for textiles in mixture with cotton - used as weft yarn.

Contains two substances which are/have been in commercial use

— anabasine [an alkaloid Uee

entry no. 31) used as an insecticide] and rutin la glycoside of the flavone quercetin).

Has been used as a source of fibre suitable for brushes, baskets, etc. Also of value as *a* range-conservation plant.

Overground parts of the shrub contain up to 0.1%

2, 6—dimethyl-piperidine and 1, 2, 6—trimethyl-ptperidine.

Grows in dry, poor soils. Leaves yield 12—14% fibre; reported to be stronger than jute and finer than sisal. Composition of waste pulp; cellulose,

58.9%; lignin, 12.7%. Was exploited during 1940s and early 1950s, when crop received some agronomic research input and also research on fibre extraction methods to give an improved fibre. Annual production in 1960s estimated at

4,000 tonnes.

Total alkaloid content of the leaveB of Argentinian plants

I.1% (mainly anabasine); US plants' average anabasine content is 0.64%. Egyptian plants have anabasine contents of: leaves, 1.09%; fruits, 1,16%; and a rutin content which at maximum (before flowering or at fruiting) reaches 1.6%. Investigated as a potential insecticidal crop in the USA during 1940s. Plant considered to have commercial potential as *a* source of anabasine artd rutin in Egypt in 1960s. Leaves of hybrid *N. rustics* x *N. glauca* reported to contain as much ss 6.6% anabasine.

Each plant yields about 14-34 kg of green leaves — and these contain on average 48% crude fibre and 43% protein. Exploited commercially as a fibre source during World War

II.

Harvesting and fibre extraction said to be problematic.

Rutin was once considered to have vitamin activity (part of the so-called vitamin P complex) and was used pharmaceutically to correct various apparent vitamin-deficiency symptoms; but its value in this respect is now largely discounted.

Fibre has rather low tensile strength.

KuioVkOVSnd Men'shikov, 1951 Petrov, 1972

Anon, 1950 Anon, 1954c Kirby, 1963 Mors and Rizzini, 1966 Santa Rosa, 1949

Barilari, 1957/58 Feinstein *et al.,* 1951 Khafagy and Metwally, 1968a Khafagy and Metwally, 1968b Krochmal er *a!.,* 1954 Martindale, 1977 Roark, 1947

Bender, 1963 Senson and Darrow, 1944 Botkin, 1945 Cruse. 1949 Duisberg, 1952a Duisberg, 1952b Duisberg and Hay, 1971 Krochmal *9t3l.,* 1954

List of plants tolerant of arid or semi-arid - Part 61

210. *Opuntii* spp.

(Cacti often known, whatever the species, as prickly pear; also as noflal or tuna)

Arid and sub-arid regions of CJ., C. and S. America; naturalised in Australia, Hawaii, Asia, Mediterranean, Africa.

211. *Opuntia cochiriHifera* IL.) Mill.;

Cultivated as host pfant for the cochineal insect from which the deep red dye is obtained (at one time Mexico was a major producer but synthetic dyes virtually eliminated this trade).

The mucilage *isee* entry no.

215) used locally as antiinflammatory agent. Fruits edible. Trial cultivation las forage crop) in Mozambique and Venezuela.

syn, *Nopaled cochiniiUfsra* 1L.) Salm- Dyck

(Nopal)

Indigenous to Mexico but now widespread in the tropics.

Used mainly for animal fodder and edible fruit production. Minor outlets which have been tried out or mooted include: as a source of adhesives, cellulose, drugs, essential oils, gums and resins, enzymes, insecticide, latex (rubber substitute), seed oil. Various parts of plant used in Indian medici ne.

Some species are hardy and frost-resistant. Twenty nine species have been examined as potential oilseeds;composition of oil varies with species — examples follow. Industrial (fuell alcohol can sometimes be obtained from the fruits: heating the must with bisulphite said to give the best results. Alkaloids isolated from Italian spp., one an anti-diabetic factor. In the USA, 2 tonnes flowers collected annually for perfume production. The plants can be grown from seeds or by vegetative reproduction.

Indications qf a renewed interest in cochineal, at least as *a* food colorant (due to the introduction of more stringent food-additive regulations}. A pectin-like mucilage (gum), considered to have commercial potential a; such, has been isolated in 0.48% yield (of ftesh whole plant) and analysed by acid hydrolysis; arabinose, galactose, xylose, rhamnose are the main sugars present.

Some species can spread rapidly and become uncontrollable weeds.

Found to be susceptible to a virus (Cactus virus X) in Venezuela

Cruse, 1949 Cruse, 1959 Cruse, 1973 CSIR India, 1966 Duisberg, 1952a, b Fernandez, 1954 Lercker er *a!.,* 1976 Lotti and Averna, 1965 Pantanelli, 1920 Reti, 1950 Reti, 1954

Anon. 1959a Baranyovits, 1978 Lloyd, 1980 Mindtera/., 1975 Myre, 1974 Uphof, 1968

Contains the hallucinogenic alkaloid mescaline (0.9% w/w of ttie whole dried plant).

21 2. *Opufitia c/lindnca* DC. Peru.

Elferink, 1974

Turner and Heymart, 1960

213. *Opuntia dillenii* (Gawler); syn. *Cactus indicus* Roxb. (Prickly pear)

C. America, naturalised in India.

214. *Opuntia a/atior* Milt.; syn. *O. nigracans* Par. ex Foerst.

(Prickly pear)

S, America, naturalised ir India (especially in W.).

Popular hedging plant since spiny and easily propagated; of local medicinal use and, after burning off spines, as cattle fodder.

As for *O. dittenii,* above.

Thrives in the poorest and driest of soils. The fruits (5,6% moisture, 41.9% carbohydrates, 32% fibre, 3.6% fat, 6,2% albuminoids, 10.6% ash) contain 8% fermentable sugar and could be a useful source of industrial (or fuel) alcohol. The plant will also yield a (poor quality) paper pulp and gum. Glycosides of flsvonoids isorhamnetin and quercetin extracted from the flowers,

CSIR India, 1966 Nairend Subramanian, 1961

CSIR India, 1966 Ganguly *et al.,* 1965

The fruits contain <dry wt. basis) 58.1 % carbohydrates, 13.5% fibre, 3.3% fat, 6.4% albuminoids (and ash etc.). Structure of opuntiol shown to be 6-hydroxymethyl-4-methoxy-a-py rone.

List of plants tolerant of arid or semi-arid - Part 62

215. *Opuntia ficus*indica* {I__> Mill

(Prickly pear, Indian fig, Sardinia cactus, tuna da csstilfa, Barbary fig I

Indigenous to C.S. America but widely naturalised.

216. *Opuntia fulgida E*ngelrn.; syn. *O. choUs* Weber

(Choi Is)

Mexico, S. USA.

21 7, *OfHintia rftegacantba* Salm-Dyck Mexico.

218. *Opuntia wigaris* Mill.

(Prickly pear. Barbery fig}

Indigenous in S. America,

Widely distributed in Mediterranean, Madagascar, etc.

Cultiv/aited mainly for the fruit. A gum Can be obtained from various parts of the plant (by extracting with water and straining) and Is used as an adhesive. I including mixed with pesticides, in a USDA-developed cotton pesticide 'formulation), and in cosmetics;main constituents, galactose and arabinose. A spineless species so can be, and is. used direct as fodder.

Cum used in Mexico as size and cloth stiffener; stem used in craft products.

Apart from use of the fruits as food and as a constituent of a fermented beverage, the stem juice is boiled vvith tallow to make candles and used locally as an anti-inflammatory agent.

Yields a gum (fee entry No. 215) which has been used with Bordeaux mixture and arsenates as an adhesive in insecticide sprays: 1 4b of the mucilage from which it is derived yields enough gum for 25 gallons of spray (i.e. 1 kg to 250 litres].

Very susceptible to attack by *Dactylopiut indiCuS,* a common cochineal insect (in India),

Has also been put to several of the other uses listed under entry no. 210.

Fruit flesh contains (dry wt, basis) 58% carbohydrate — from which industrial (fuel) alcohol can be obtained by fermentation - and a yellow betaxanth in -type pigment, indicaxanthin (also betanin — violet). The fruit juice contains 0.04% vitamin C and reportedly a trace of carotene (?). The seeds give 6% semi-drying oil (iod. val., 125) and a 'nutritious' oilcalce which can be used as a fodder (12% protein, 5% fat,

11% fibre, 21% ash, 14% moisture, rest carbohydrate, etc|. Leaves contain 0.3% triterpenes and sterols lincluding sapogenins).

Alcohol fermentation said to proceed only slowly.

A high yield of almost pure, white cellulose (76—81% ftcellulpsfi) can be obtained (apparently from the whole plant.)

Gum exudate consists of L-arabi nose (6 parts), D-xylose (2 parts), D-gglactose (3 parts), P-galecturonic acid (1 part). Resembles other plant gums. Acid hydrolysis of gum yields glucose (and other reducing sugars) and pentosans. Gum is soluble in aqueous ammonia or alkali.

A gum reported to be obtainable Use previous *Opuntia* entries).

Four triterpenes isolated from (whole) plant: friedelin, friedelan-3a-ol,taraxero(and taraxerone. A flavonoid glycoside can be extracted from the dried flowers in 2% yield and has rutin-like Uee entry no. 208) and also anti-diarrhoea activitv. Alkaloids containing ^■phenylethylamine skeleton present. Fresh stalks yield, on water extraction, 0.7% of a pectate said to have anti-haemorrhage activity. Seed contains *8%* oil, sp. gr. 0.918, iod. val., 103. Main constituents of the gum are arabinose and galactose.

Amin *et al-,* 1970*17*1 Anon,1934 Cruse, 1949 Cruje, 1973 CSIR India, 1966 Deplan o, 1932 Fernandez, 1954 Krochmal *it at.,* 1954 Minaleefa/., 1965 Mukerji and Ting, 1968a Mukerji and Ting, 1968b Piatelli ef *at,,* 1964 Tawfiktffa/., 1978 Uphof, 1968

Bel an I, 1934 Brown *et* a/,, 1949 Duisberg, 1952a Duisberg, 1952b Uphof, 1968

Churmsffta/., 1973 Uphof, 1968

Chatterjeeira/., 1976 CSIR India, 1966 Paris, 1951 Heti, 1950

List of plants tolerant of arid or semi-arid - Part 63

Name(s)/Distribution	Current/past uses	Potential	Constraints	Citation data
219. *Osteospermum* spp. S. Africa, St. Helena.		Small annuals to shrubby perennials. Seed oil of 14 species (not all AZ species) surveyed and found to contain 2—48% conjugd. trienoic acids and up to 60% dimorphecolic acid. (For its structure and possible industrial uses (in plastics, paints, etc: cf. castor oil), *see* entry no. 107).	No species at present suitable for modern cultivation methods but variability in range suggests possibility of developing suitable lines (spp. of the Blaxium section of the genus considered to have the best prospects; *O. ecklonis*, *O. caulescens* and *O. jucundum* merit attention).	Barclay and Earle, 1965 Earle *et al.*, 1964
220. *Osteospermum muricatum* E. Mey. ex DC. S and E. Africa, Arabia.		Oil content of seed, 6–11%, protein, 11–12%. A perennial bush with good achene production and which is drought-resistant and adaptable to semi-arid regions.	The achenes are situated below the crown of the shrub.	Barclay and Earle, 1965 Jones and Earle, 1966
221. *Osteospermum sinuatum* (DC.) Norlindh S. Africa.		Oil content of seed, 39–42.6%; protein, 41.9–44%. The oil has iod. val., 140 and contains 32% conjugd. trienes (by U.V.) and 2% dimorphecolic acid (*see* entry no. 107).		Earle *et al.*, 1964 Jones and Barclay, 1972
222. *Osyris* spp. (E. African sandalwoods) Mediterranean; Africa to India.	Leaves of E. African spp. used as source of sandalwood oil. *O. abyssinica* Hochst. ex A. Rich. a source of tanning material. Little known of botanical origin of E. African sandalwoods. Some spp. used as timber.	Seed oil has similar composition to those of other Santalaceae [and interesting in that they provide one of the few known sources of acetylenic fatty acids (*see* next entry) whose reactivity may have industrial potential (cf. uses of acids such as dimorphecolic: entry no. 107)].		Guenther, 1952 Guenther, 1968 Mensier, 1957
223. *Osyris alba* L. (Gardrobe, poets' cassia) Mediterranean (common in S. France).		A shrub. Seeds contain 36% oil, 11% protein. Oil has iod. val., 117 and major component is an acetylenic acid — probably ximenynic (11-en-9-yn-C_{18}), 57%; also oleic, 32%; linoleic, 2%; linolenic, 2%; stearic, 3%. Various parts of plant analysed for phenolics and flavonoids and the following identified: para-hydroxy-benzoic, isoferulic, proto-catechic and para-coumaric acids; also 'rutoside' (rutin: *see* entry no. 208).	Semi-parasite.	Jones and Barclay, 1972 Mikolajczak *et al.*, 1963

List of plants tolerant of arid or semi-arid - Part 64

224. *Parki'nsonia aculeate* L.[f]

225. *Partftenium argentatum* A. Gray (Guayale)

Indigenous in Mexico and Texas (especially the Chihuahuan Desert of SW. Texas and N, Mexico).

Nil currently (experimental plots only — in Israel, Ariiona and California), but was cultivated in USA during World War II as part of emergency programme to overcome shortage of natural *Haves* rubber at that time, and wild stands were processed for rubber on a large scale in Me*teo from 1905 to *circa* 1925. Was used for making vehicle tyres and many other commercial rubber products.

A frost-tolerant [15° F!-10°Cl a safe minimum for mature plants) shrub whose roots penetrate 20 ft (6 ml in arid areas and which will live 30+ years. Contains a late* dispersed throughout much of the plant except the leaves (including one-third in the roots) and which yields a high-quality rubber; yield "V 10% of total plant dry wt, usually, but over 209fi found in some strains. Can be harvested mechanically — either the whole plant or the top is mown off and the stump allowed to regrow, Extraction of the rubber is straightforward.* A disadvantage of the pre-1946 rubber mas that the resin that remained in it reduced its quality; but since then a method of washing this out with e.g. acetone has been discovered and this gives a product which is virtually indistinguishable in all properties (tensile strength, chemical composition, etc.) from *Hevea* rubber — and better for most applications than synthetic rubber. On a smell scale, retting (spontaneous microbial action on stored wet shrub material) can be used instead of acetone-washing. Yields of 1 3—1.7 tonnes/ha p a. of rubber recorded from mature cultivated (but partially irrigated) guayule, and although much slower production during drought, the rubber still slowly accumulates and does not deteriorate even if the shrubs are not harvested for some years. Demand for natural rubber (which for certain applications, especially alone or blended in tyres, cannot be replaced by synthetics) predicted to continue rising during 1980s at SW or more p.a, and to outstrip likely supplies of *Hevea* rubber, thereby possibly allowing guayale to return as a major commercial source — and s source derived from areas with a far less amenable environment than *Hevea* needs. Many possible guayale byproducts. Thus the shrubs also yield many, though small, seeds which may have oil and protein potential. Also, for each tonne of rubber won, around *2* tonnes wood fibre (bagasse), 0.5 tonnes resins, 1 tonne leaves are left. The

Restricted to well-drained nonacid soils and needs 250 —

380 mm rain p,s. for worthwhile growth — which for good rubber yields must include a definite dry period in the winter to stress the plant. Doubtful whether it would survive the long hot dry summers of e.g. the Sahel. Seeds must be pre-treated, with hypochlorite, to remove natural inhibitors; and the seedlings (best raised in a nursery) grow slowly, need frequent irrigation until established (but avoid waterlogging which encourages fungal attack), and are easily overwhelmed by weeds which must be controlled manually, mechanically or by herbicides. Rubber content of wild stands very variable (but this should be countered, when cultivated, by breeding). Latex distributed in single cells not ducts so cannot be tapped and the whole plant, or its aerial parts, must be harvested- Both forms of harvesting (digging up or mowing) have disadvantages in arid areas: the first leaves the soil bare and prone to erosion and with the second the plant

Anderson, 1982 Archer, 1979 Buchanan *et a!.,* 1978a, b Calvin, 1978 Campos, 1975 Checheinitrky, 1975 CONACYT, 1978 Cruse, 1949 Duisberg, 1952a, b Duisberg and Hay, 1971 Feustel and Clark, 1950/51 Forti, 1975

Hammond and Polhamus, 1965 Hanson *etai.,* 1979 Hendrickson and Rees, 1962 International Rubber Study

Group, 1978 Johnson 1977 Johnson and Hinman, 1980 Laguinge, 1951/2 Lipinsky, 1978 McGinnies, 1975 McGinnies in Davis, 1978a McGinnies and Haase, 1975 Mears and Larson, 1982 Meeks et *at,* 19S1 National Academy of Sciences.

1977b Rodriguez *et* <»/., 1981 Schechter, 1975 Vietmeyer, 1979 Weihe *et at.,* 1979

' Shrubs dipped in hot water (to coagulate the rubber and remove unwanted leaves and root soil), milled/pulped in presence of caustic soda solution, the crude rubber aliowed to separate (by rising to the surface), collected, washed, extracted with warm acetone to remove resin and dried by passing through a screw press and then hot air drier, [f] denotes a potential firewood source (see Introduction I

List of plants tolerant of arid or semi-arid - Part 65

Current/past uses

Potential

Constraints

Citation data

Name(s)/Distribution

Parthenium argentatum icontd)

226. *Parthsmum incanum* HBK. (Mariola)

Arizona, Texas,

fibre may yield pulp adequate at least for tower quality paper or cardboard. The resins comprise 10-15% of the plant dry matter and consist of Cio. Cl 5, C20 terpenes lindudirtg diterpene acids), glycerides, hydrocarbon polymers — variously of potential use as paper sizing and as turpentine substitutes; in addition, a high yield of the cinnamate ester of partheniol (a bi-cyclic (5+7— mem be red rings) sesquiterpene] has been recovered and may prove to be a useful intermediate in chemical synthesis. The leaves yield (2.5% dry wt.)- a hal'd white wan with s m.p. (76^{c}Cl even higher than carnauba. Steam distillation of leaves and/or resin yields a volatile oil containing the above-mentioned terpenes (including the pinenes, limon-ene, etc,} and having a spicy odour. The dried plant burns fiercely due to its high hydrocarbon content and may prove to be a useful energy source — either locally as such or, or a larger scale, by initial conversion into a substitute liquid fuel. It is browsed in the wild and it may be of use as forage, as a windbreak, or to check erosion. Guayule is considered sufficiently important to warrant a regular international conference (Consejo Nacional de Ciencia *y* Tecnologia (CONIACYT) 1978). It is very amenable to hybridisation with other *P.* species *(incanum. stramonium*, etc: jee next entry! and it was said in 1977, that such exports may be the key to its future exploitation,

***A* low shrub growing at 2,500—5,000 ft (800—1,600 m) in same areas as guayule but more abundant than guayule itself; also appears to have a less restricted range than guayule. Contains only a small percentage of rubber Hess than 1% of benzene extract obtained; another result gave rubber content of whole plant, 0,28% I; but often hybridises in the wild with guayule and has been deliberately hybridised in plant breeding experiments designed to increase the size of the resulting shrub above that normal for guayule itself.**

tends to desiccate and not regrow. Unlike *Hevea,* contains no natural anti-oxidant and so must be processed fairly quickly after harvesting. Processing requires supplies of water and, except as indicated under 'Potential', a deresinating solvent. Raising seedlings and planting out needs much labour. Research needed on quality control of the rubber and on by-product uses, though much already being done by e.g.

CIQA (Saltillo), US tyre manufacturers, etc. Possible health hazard in the cultivation and processing of guayule due to the presence of allergenic terpenes.

Of little value itself as a source of rubber.

Hail and Long, f921 Hanson *et* a/., 1979 Polhamus. 1957

List of plants tolerant of arid or semi-arid - Part 66

227. *Psctii pappose* Harv, & Gray (Foetid marigold, chinchweed) SW. USA Mexico.

228. *Pedilantbus pavonis* (Klotzsch

4 Garckel Boiss.

(Candelilla plant)

Mexico, Texas.

List of plants tolerant of arid or semi-arid - Part 67

A bushy plant growing from sea-level to 4,000 ft (1,300 m) and used by American Indians for perfume, as a dye and for flavouring food. Has been cultivated experimentally.

A minor source of 3 candelilla wax (which however is chiefly obtained from *Euphorbia antiiyphiiitica'*- entry no. 127). Wild plants are collected for their coating of Max, which is used for making candles and as a substitute for carnauba and beeswax in many industrial products. The exploitation has been destructive to the wild stands. The wax is extracted by heating the waxy stalks in boiling water, most extraction plants being in Mexico and in Texas,

The essential oil of the leaves has a pleasant lemon fragrance. Plant yields 7.5 tonnes/ha of green wt. (irrigated fields) and 040-0£0% of oil, on green basis, is obtained by steam distillation (1% on dry wt. basis). The seeds have a spicy flavour and ore produced abundantly,

170 kg/ha. Approximate composition of oil: terpenes, 25%: aldehydes, 50%; ketones, 25%. Of the constituents pinocarvone is 20%, earvone, 5%, and a terpene hydrocarbon (probably (3-pinene), 25%. Cuminaldehyde {p-isopropylbenzaldehydel content the same as in cumin oil, 47.OK.

Contains 3.5—5% wax. Domestic production said to be worth consideration. Is stated to have emetic, purgative and emmenagogue properties.

Fresh seed has low germinating power (but after storage, germinates welt!. Control of weeds a problem.

Experimental work on cultural techniques, processing and economics desirable.

Bradley and Haagen-Smit, 1949 Duisberg, 1952b Krochmal *etai.,* 1954

American Wax importers, and Refiners Association, 1971 □uisberg, 1952b Duisberg and Hay, 1971 Hodge end Sineath, 1956 Krochmal *et a!.,* 1954 Uphof, 1968 Wastfer *et a!.,* 1953

229. *Peganum hatmaia* L.

(Harmel, harmal, harmala, Syrian rue, wild rue, henna!, harmara, hurmur, isbendlahouri)

Mediterranean area, C. and SE. Asia,

230, *Pen'pioca laevigata* Ail,; syn, *P. angus tifolia* Lab ill.

Mediterranean region; Canaries, Grown widely in Egypt.

A shrub common in dry waste places. In India and Pakistan, the dried seeds (known as 'harmal') are sold as an anthefminthic, narcotic, stimulant, febrifuge, diuretic, aborti-facient, and for treatment of asthma. Is also used in the form of a powder of The dried roots. Harmine, from the seeds or roots, has been used against encephalitis and Parkinson's disease. Roots are used in the USSR for treating rheumatism and seeds burnt as a fumigant. The seeds yield (12-14%) a semi-drying oil known as Zit-el-harmel, used locally medicinally and for making soap. The seeds for fruits) are used as a source of a red dye,

'Turkey red' (used in Turkey for dyeing tarbooshes, which are a kind of hat).

On dry wt. basis, ripe seeds contain 3.8—5.8% alkaloids; the fruit, 4.4%, twigs, wood and leaves. 1.0 — 1.3%; bark, 2.2%; and roots, over 3%. These consist of three indole alkaloids (the ’barman alkaloids': harmine; its dihydro* derivative, harmaline, harmaloi) and a group of quinaz-oline alkaloids (vasicine (peganine), etc). Much work on the biosynthesis of several of these reported during the 1960s and 1970s. and so-called 'harmidine' identified as harmaline. The harman alkaloids have a similar action to quinine and potentiate the effect of small doses of amphetamine; in addition to current usage, they are also said to be lethal to moulds, bacteria and internal parasites, and have been suggested as algae- and protozoa-con-tro ling agents, coronary dilators and, in vapour form, as insecticides (ineffective by contact), Harmine can act as an acid/base fluorescent indicator in analysis. Vasicine causes broncho-dilation {? use as expectorant). The seed ail is said to be non-toxic when fed to rats and has been suggested as *a* component of salad and cooking oils and for the industrial production of alkyd resins. It has iod. value, 120 and fatty acid composition (approximate); oleic, 40%; linoleic, 38%; other unsats., 2%; palmitic and stearic, 20%; and contains 'V5% unsaps, ((J-sitosterol and paraffinic hydrocarbons). Leaves said to contain 80 mg/ 10Qg vitamin C. A new amino-acid, pegaline ICeHnOaN), has also been reported present.

A small shrub, laticiferous. The Oily material obtained (1.14% yield by solvent extraction of the whole dried shrub), contains 53% unsap. matter and 46% fatty acids (which include oleic, linoleic, linolenic, myrigtic, palmitic, stearic, arachidic, behenic and lignocericK Unsap. fraction contains |3-sitosterol, campesterol and stigmas-terol (the u;ual plant sterols). Aerial parts contain carbohydrates, tannins, cardiac glycosides, unsaturated sterols, flavonoids, oxidases (but no alkaloids or volatile oils).

The seeds are toxic due to alkaloid content and the plant is thought to have led to the death of browsing animals on occasion (but is generally rejected as unpalatable); as with many alkaloids their use as a drug needs careful dose control (can cause tremors, CNS depression, failing respiration, etc.).

Chatterjee and Ganguly, 1968 CSIR India, 1966 Groger and Mothes, 1960 Hassan, 1987 Hocking, 1966 Ikram and Islam, 1963 Indian Standard, 195S Javedot *al,,* 1972 Khasimov *et a!.,* 1969 Koretskaya and Utkin, 1958 Kutlu and Amal, 1967 Liljegren, 1971 Mensier, 1957 Nadkarni, 1954a Paul *eta!.,* 1960 Robinson, 1965 Schipper and Volk, 1960 Schmitt and Schmitt, 1964 Siddiqui, 1962a, b Siddiqui and Kemal, 1964 Uphof, 1968 Zetler *etat.,* 1972

Ahmed sr *at.,* 1969

List of plants tolerant of arid or semi-arid - Part 68

Constraints

Potential

Current/pass uses

Name (s)/Distribution

231. *Physocfilaina praealta* Miers. (Laltang)

N. India.

232. *Pimpineita artisum* L.; *syn. Annum votga/e* Gaertn.,

A *officinarum* Wloench.

(Anise plant, anissad, sweet cumin)

Greece, Egypt. Widely cultivated in Europe, Asia, M. America.

An erect perennial herb which grows wild, and abundantly, in the high dry valleys of N. India (e.g. Ladakh). The seeds are used locally as a vermifuge.

An annual herb 30—60 cm high. Whole fruits are distilled to produce essential oil which is used widely in flavour* ing, liqueurs, mouth washes and as anise milk. The oil is also used externally as a mild insecticide and fungicide.

Seeds used medicinal l v as an aromatic stimulant, etc. Distillation residues have some food value and can serve as stockfeed.

Leaves of wild plants contain 1% or more alkaloids — mainly hyoscyomine; but experimental cultivated ptants at 5,000 ft (1,600 m) were stunted and contained only 0.2% alkaloids in the first year and 0.7% in the second. Being a perennial plant, the leaves can be harvested repeatedly (for sun-drying when they are either powdered and used as such — giving a belladonna-like pupil-dilating effect — or used for extracting the hyoscyamine (which in turn can be converted into the drug atropine)). The roots also contain alkaloids — around 0.6% w/w.

Under favourable conditions yields 400—600 lb seeds/ acre (450—700 kgAia). These give, ideally after crushing, on steam distillation, 1,5—6% (usually 2—3%) essential oil — known as anise oil. This contains 80—

90% anethole (methyl ether of p-propenylphenol), methyl-chavicof (its p-allyl isomer), and traces of various terpenes. The seeds also contain 'V 10% moisture, 18% protein, 12-25% fibre, 6-10% ash, 26% carbohydrate, and Iby ether extraction after iteam distillation removal of the essential oil) up to 26% greenish oil containing 1-2% unsap. matter and with sp. gr., 0.923-0,930; sap. val., 178-188; iod. val., 102-106; fatty acid composition: oleic, 66%; petroselinic (the A® isomer of oleic (A^9) and convertible into the possibly useful intermediate 6, 7— dihydroxy stearic acid), 24%; linoleic, 17%; palmitic, 3%. it has been suggested (1963) that The essential and fatty oils could be extracted simultaneously. Pharmacology and veterinary usages have beer described.

Natural habitat 9,000

11,000 ft 12,700-3.300 ml altitude; full height not attained at 5,000 ft (1,500 ml and cultivated plants apparently contain less hyoscyamine than wild, Prefers a hucnus-rich soil. High collection and transport costs from the high remote arid areas where it grows satisfactorily make its exploitation uneconomic.

The leaves are narcotic to man and some animals (but are used as fodder for others).

An annual plant having a long vegetative period which necessitates sowing earlier than other crops. Progressive ripening of fruits presents harvesting problems, Although classified as a desert plant by Arnon, it requires periodic irrigation or rainfall in growing season, is susceptible to extreme climatic conditions and is difficult to mature in hot. dry regions. Susceptible to attack by the insectSyrra/fl *slhipsnnh.* The anise oil of commerce is frequently

adulterated with the cheaper, and inferior (harsher odour), oil derived from *Illicium verum* (known as star anise oil'). Anise oil slowly deteriorates on prolonged exposure to air and light (? due to oxidation/polymerisation) and similarly leaves a residue on evaporation in an open dish.

Arnon, 1972 Chopra *et aL,* 1960 CSIR india, 1969 Handa eta/., 1951 Kapoor etW., 1963 Sarin at *at.,* 1963

Anon. 1961a Anon, 1962c Arnon, 1972 Ayensu, 1979 CSIR India. 1969 Dublyanskaya, 1964 Guenther, 1950 Mensier, 1957

Rakoto-Ratsimamanga *e(at,,* 1969

Topalov er *aL,* 1963 Uphof, 1968

List of plants tolerant of arid or semi-arid - Part 69

233. *Pinus ha/epertsis* Miller'

234. *Pirbecellobium dulcc* (Roxb.) Benth.[1]

235. *Plantago ovata* Forssk.; syn. *P. decumbens* (Spogel plantain, ispaghula)

Mediterranean, SE. Asia,

236, *Proboscicfea parviftora* (Woot.) Woot. *St* Standi.;

(probably syn. **with** *Maftynia* ***parvi flora*** **Woot.)**

I Devil's claw)

Native of SW, USA deserts.

The dried seeds are known as ispaghula or isubgol. The seeds have a mucilaginous husk, which can be separated out by crushing the seeds and then sieving, which swells (to a gel of 25—50 tirrtes the volume) on mining with water. The mucilage is the active principle for the main current use of this plant, namely of the husk or whole seeds, as a gentle laxative and emollient, both in local Indian medicine and exported (especially to the

USA). In 1976-77, 4,770 tonnes of husk exported from India. The mucilage is also used as a stabilizer in ice-cream manufacture, in cosmetics, as a thickening agent, in printing and, after treatment with caustic soda solution, as an agar-agar substitute.

Herbaceous oilseed plant: grows wild in SW. USA deserts up to 4,000 ft (1,200 m) or higher, but is also cultivated in Indian reservations, Fibre used in basketry.

The gel-forming properties of the mucilage are superior To those of many other gums ■ and hence is a potential replacement for these. It consists of 3 mi xture of polysaccharides containing mainly icylose, arabinose and galacturonic acid units. The seeds also contain a yellow semi-drying oil (5%) with sap. val., 182; iod. val., 116. 2% unsap. matter linclucting f3-sitostero11; fatty acid composition: oleic, 37%; linoleic, 48%, palmitic, 4%; stearic, 7%; lignoceric (C_a4 sat.); 1% (the high acetyl val. reported, 37.7, implies a significant % mono/diglycerides and/or undetected hydroxy-acids present).

Potential of 1,000 kg oil/ha. The oil (36% of seed wt.) has a high linoleic content: overall has a similar degree of unsaturation to safflower oil - hence should make a good drying oil. Stiff-stal ked lines with an erect habit have been bred, A recent study concludes that domesticated it could be developed into a valuable oilseed for arid lands.

Naturally an ephemeral but is cultivated in India and Pakistan (when it needs occasional rain or irrigation to germinate and develop}. The fruits must be harvested by hand (ideally in early morning when slightly damp) as the plants have weak stems and also shed their seeds readily. Does not do well in very hot conditions.

Arnon, 1972

Chandler, 1954

CSIR India, 1969

Maheshwari and Tandon, 1959

Martindale, 1977

Mithal and Bhutiani, 1969

Mithai and Zacharias, 1971

Modi *et <>1.*, 1974

Paroda, 1979

Uphof, 1968

Berry *et a!.*. 19S1 Krochmal *eta!.,* 1954 Natohan *et al.* in Davis, 1978c New Mexico Agricultural Experiment Station, 1954

List of plants tolerant of arid or semi-arid - Part 70

[f] denotes a potential firewood source (see Introduction)

237. *Prosopis alba* Griseb.[f]

238. *Prosopis chilensis* (Mol.) StuntJ[f]

239. *Prosopis cineraria* (L,l Druce[f];

syn .*P. spiogera* L.

(Musquit bean, screw bean, Jandi, Khejri)

Iran, India, Afghanistan.

*** The Hydrophile-Upophile Balance — a measure of the effectiveness of an emulsifying agent as when used e.g. in pharmaceutical preparations; acacia gum gives a value of 11.87 (W. L. Guess, *J, Pharm. Set.,* 1961, 50, 238).**

[f] denotes a potential firewood Source (see Introduction)

List of plants tolerant of arid or semi-arid - Part 71

A small tree of up to around

12 m in height. Pods used in various 'foods {such as curries) especially by desert dwellers. Gum, which exudes from cut stems, is eaten and marketed, like that from several *Prosopis* spp., as 'mesquite gum'. In many areas, the branches are cut off annually and used lor fuel: the wood is said to be excellent for this and also to give a high-quality charcoal. The ash s a rich source of potash. The wood is also occasionally used for wagons, implements, furniture, etc,

(but thars are constraints on its use outdoors). The leaves are regularly lopped for use as fodder and are also Composted. A fibre, sarmdal, is sometimes made from the bark. The plant is used in Indian medicine for rheumatism etc.

Grows well in India even where rainfall is only 100 mm p.a. and will regenerate via suckers in such areas Iseeds need more moisture). The gum is similar to gum acacia and can be used as a substitute though it has the slightly inferior HLB value* of 9.3—9.4. Acid hydrolysis yields the sugars arabinose, galactose and rhamnose end *a* uronic acid. Ethanol extraction of the heartwood yields

0-5% material containing 26% sugars {sucrose, glucose, fructose, arabinose and marmoset a large amount of tannin, several flavones, and 0.5% ^-sitosterol. Patulitrin has been isolated from the flowers and a mixture of Cscj—60 wax esters (of possible interest), the usual plant sterols ((3-si to -, stigma-, campe-l and a piperidine alkaloid tepicigerine) from the leaves, and various flavones from the seeds.

The timber is not very durable and is susceptible to insect attack. It has 11967) no large-scale commercial use.

Bhardwaj *et at,* 1980 CSIR India. 1969 Jewerser *a!.,* 1976 Kaul and Ganguly, 1962 Khasgiwai *etzt.*. 1969 Khasgiwai *ex al,* 1970 5arwar ***et al.,* 1967** Sharma **er *al.,* 1964a Tewari, 1979 Uphof, 1968 Wadhwani, 1953**

240. *Prosopis juliflora* [SW) DC.* {sometimes recorded as *P. gbndutosa* Torr, and by some authors as *P. cbitensis* var, *glandulosa*! (Torr.) Standley

(Mesquite)

Tropical America, Africa (naturalised in Egypt), and parts of Asia.

SmaU {up to 10m) thorny

tree which is a prolific seed bearer (90 kg/tree at 10 years I. Its bark exudes a sum Cmesquite gum') which is edible and is used in the manufacture of mucilages and confectionery and as an emulsifying agent. The bark is also used for tanning. The timber is used for fuel, fence posts (resistant to rotting I and occasionally for conversion into charcoal. The wood flour has been used as an extender for phenolformaldehyde plastics. The ripe pods are used locally as food and more widely as fodder {dry wt. analysis — fibre, 30%; digestible protein, 6.9%; carbohydrate, 50%; fat, 5%; ash, 5%) as are the leaves (sir-dried have protein, 26%; fibre, 25%; moisture, 7%). The flowers yield nectar and honey. Leaf extracts used medicinally

locally.

Method of providing cover for bare arid land {providing it car be kept under control), and. being leguminous, increases soil nitrogen content (by 2—2.5 times). Acid hydrolysis of the gum, a water-soluble polysaccharide, yields mainly arabinose, which can be easily separated so making a useful source of this sugar, plus some galactose and glucouronjc acid. The fruits contain the flavonoid patulitrin and free sugars {glucose and sucrose). Could be a useful

multi-purpose plant: in addition to the established uses (left) and indicated previously, it has been suggested that the timber could be used for the production (by acid hydrolysis -- as used on cellulose wastes) of alcohol Ifor fuel) or acetic acid, of single cell protein for use in feeds (by aerobic fermentation), to make fibreboard, as a paper-making materiel, and finally of producer gas by dry distillation. Most parts of the tree contain tannins: 0.9% in the dry wood, 3.0-8.4% in the bark and 6-7% in the roots. The seed; contain {dry wt-) 6 6% oil and 39,9% protein, but negligible tannin.

An aggressive, rapidly spreading (especially where animals browse it and spread the seed in their droppings) weed; has overwhelmed large areas of grassland in e.g. Mexico. Attempts frequently made to eradicate it in various arid areas. Is partially controlled by heavy browsing but is little affected by insect pests being generally resistant to them. Extensive root system strips surrounding ground of its available moisture. Intensive use in fodder for cattle leads to malnutrition in them. The gum is considered inferior to gum arabic (see entry no. 3). Tannin contents considered unworthy of exploiting (1960 ref.).

Arnon, 1972

Aykroyd and Doughty, 1964

Brookbank, 1976

Cruse, 1959

Cruse, 1973

CSIR India, 1969

Cuneenand Smith, 1948

Duisberg, 1952a, b

Feiker, 1979

Gianinetto *et at.*. 1975

Gowda and Ramaswamy, 1960

Graziano *etai.*. 1971

Guha ef a/., 1970

Jones and Earle, 1966

Krochmal *etai.,* 1954

Laundrie, 1958

Marshall, 1947

Morton, 1963

Parker in Davis, 1978c

Parker and Martin, 1952

Ratle *e-r* a/,, 1966

Smith, 1951

Thayer, 1979

Uphof, 1968

Wassel ef *a!,,* 1972

Whitford ef $/,, 1978

Wright in Davis, 1978c

List of plants tolerant of arid or semi-arid - Part 72

241. *Prosoph paiiida* {Willd.) HBK*

242, *Prompts Umarugo i.* Phil.*

[f] denotes a potential firewood source *{see* Introduction)

243. *Pyrethrum santotinoides* DC ; syn *Tanacetum sinaicum* Delile e* DC.

Israel land to the south thereof)

244. *Rhamnus catharticus* L.

Seeds (which have wt./1,000 of 13,1g) contain 20% protein Tends to prefer relatively we

(Common buckthorn, purging buckthorn)

Europe, Asia, N. Africa.

245, *Rheum emodi* Wall, ex Meissn. (Indian rhubarb, Himalayan rhubarb!

N. India.

Shrub or small tree; wood used for making small wooden articles by lathe; berries used as source of a purgative (e.g. in the linctus known as Siruptis Rhami catharticae) and of a dye known as sap green.

A herb 2-3 m high. The rhi2omes and roots have purgative action (due to the presence of senna-like compounds! and are astringent

— and are used in Indian medicine.

'High' (but unspecified) essential oil content; has been under investigation in Israel.

and 25% of a drying oil which is greenish with an unpleasant taste and which has sp.gr., 0.919; sap. val. 185; iod. val. 160; fatty acid content: linoleic, 35%; linolenic,

25—30%; Oleic, 20—30%; sats, 10%. Seeds also contain kaempferol, a yellow flavone responsible for their colour; berries contain the closely related f lavone, rhamnetin. Purgative action due to anthraquinone derivs. (emodin etc,)

The rhiiomes and roots contain a mixture of substituted anthraquinones and their glycosides (such a: emodin and its derivatives, the sennosides, etc.), which are responsible for the purgative action, and phenolics {gallic acid etc.), the cause of the astringency. Steam distillation of roots yields 0.05% essential oil whose characteristic odour is due to eugenol. The rhizome also contains a little tannin, and 5—6% water-soluble mucilage.

No recent references found, suggesting earlier promise not fulfilled.

watered areas. Remarks made under entry no. 73 (senna) probably also applicable here.

The plant is 'drought resistant' but is restricted in nature to the slopes of the Himalayas between 3,000 and 5,000 m (though has been cultivated lower down) and is barely within the scope of this compilation. The plants have to be 6—7 years old before the rhizome is collected,

Zaitschek, 1953

Ayensu, 1979 Earle *et al.*. 1960b Jones and Barclay, 1972 Mensier, 1957 Oesch and Perkin, 1914 Paris and Dillemann, i960 Uphof, 1968

CSIR India, 1972 Mukerji, 1943 Nadkarni, 1954b Voungken, 1946

List of plants tolerant of arid or semi-arid - Part 73

Potential Constraints

246. *fticinodendron rautanenii* Schin^.

(Manketti, mcmgongo)

Angola, Botswana, Zambia, **Mozambique.**

247. *Ricinus communis L.*

(Castor oil plant, palrma Christi)

Widc'y in tropical (and some subtropical) regior.$,

A trfti; 10—16 m in height, the fruit and nut of which are important in the diet of Kalahari-desert bushmen. The seed oil can be expelled by pressure. The fruits are also distilled to make alcohol.

Very variable shrubby plant

1—8 m in height. Cultivated on a *very* large scale in Brazil, India, etc,; total production around 800,000 tonnes seed p.a. worldwide. Oil content of seed, 40—50%. The oil is almost pure (around 90%) ricinoleic acid triglyceride and is a major industrial product being both used as such

Grom? well in 'Kalahari sand', especial ly along the crests of sandy ridges, where rainfall is 150—600 mm p.a. (but 200 mm is adequate and it can 'withstand long droughts'), The tree bears fruit after 25 years and can be propagated either from the kernel or veqetatively, The kernel, which is edible and is 9% by wt. of the fruit, has high fat (57,3 g/ 100 g) and protein content [28.8 g/ICO g). A mature (female) tree y leltfs up to 950 fruits. The seed Oil is pale yellow and is semi-drying: a solvent-extracted sample had (196 7): density (at 20^ C), 0 960; sap- val,, 1 93 ; iod. val,, 156; fatty acid composition: sal. acids, 13%; linolemc,

3%; linoleic, 44%; oluic, 17%; elaeostearic 1C 10 containing a conjugd, iriene unit), 23% [confirmed by u.v. spectrum). The oil when fresh is said to be edible and to have a pleasant taste. Its relatively high unsaturation may make it of some use in the manufacture of paints and varnishes. The oil cake contains 60% protein. The wood is soft and light, a substitute for balsa, and can be used for matches and insulating boxes, Paper-making experiments show generally good mechanical properties. Board-making experiments have also been conducted.

Said to be one of the few crops in India wh ich will grovu economically on poor gravelly soils. The oil is unusual in being almost entirely one chemical species (hence no separation problems) from which almost pure ncinoleic acid cart be obtained on hydrolysis. This acid has several functional groups and SO has high potential as the raw material for the production of various chemical compounds. Some are already in use on a large scale *tsee* left) but others could follow. Pyrolysis of castor oi I said to produce a useful pyrethrjm synergist.

Restricted in nature (though could presumably be cultivated in similar areas) to sub-tropical latitudes of S. Africa and sandy well-drained oi Is. Tolerant of semi-arid rather than arid regimes. The wood is too lightweight for building. The nutshell is very hard to crack {requires an initial roasting).

Only 35% of the whole f ruit is edible 126% flesh, 9% kernel) the remainder being shell and skin. The seed oil is not likely to find gener al acceptance as an edible oil on a commercial scale as its high elaeostearic acid content w ill lead to its rapid deterioration (by polymerisation of the triene function) on storage or heating At the same time its Occurrence in greater preponderance in ft, *heudelotii* seed oil l'V> 50%) and in tung oil (70—30%) means that *R. rautanenii* is hardly likely to be a viable source of this potentially interesting fatty acid,

Said to prefer fertile, deep, well-drained soils and rainfall of 400—500 mm in 6 months followed by dry periods but there are many forms (? subspecies) which vary in water requirements. However, has poor tolerance to salt and is sensitive to frost. The various severely toxic constituents of the seed, which remain in the

Adrian *a!.,* 1955 Anon, 1951c Anon, 1959c Bieseie *et al.,* 1979 Chisholm and Hopkins, 1966 Chittenden **et a/.,** 1960 Lee, 1973 Mensier, 1957 Perrotf e(*a!.,* 1967 Xabregas and Teixeira, 1952 Xabregas *et a!.,* 1967 Xabregas, 1957 Uphof, 1963

Anon, 1942b Anon, 1943a Amon, 1972 CSIR India, 1972 Duisberg and Hay, 1071 Godin and Spensley, 1971 Hinkson *et a!.,* 1972 Jones and Earle, 1966 Layton, 1977 Macfarlane, 1975 Mensier, 1957

List of plants tolerant of arid or semi-arid - Part 74

Name(s)/Distribution	Current/past uses	Potential	Constraints	Citation data
Ricinus communis (contd)	(medicinally, as a purgative, and industrially, in lubricants, brake fluids, cosmetics, and in the production of crumb rubbers and speciality soaps) and as a raw material for the manufacture of: a) Sebacic and undecylenic acids, used in making synthetic resins and fibres (nylon). b) Dehydrated castor oil (DCO), made by acid-catalysed dehydration, with a higher iod. val., (110) than castor oil itself (85) and hence a valuable semi-drying oil; used widely in the manufacture of paints and varnishes. c) Turkey red oil, made by treatment with cold sulphuric acid, widely used in the textile industry. d) Hydrogenated castor oil — used as a substitute for carnauba wax and in the formulation of greases, etc. The oil cake is used as a fertiliser (castor pomace). Stems used as fuel, in building and as source of cellulose for manufacture of cardboard, newsprint etc. Leaves used as feed for silkworms in India.		cake on expelling the oil, prevent the cake's use as a feed (though research on heat and/or chemical detoxification, is continuing). The 1940s suggestion that castor may be a useful agricultural pesticide has faded with the introduction of modern synthetic pesticides.	Paris and Dillemann, 1960 Perrot and Gentit, 1921 Rao, 1970 Rautou, 1958 Roark, 1947 Uphof, 1968 US Report to Congress, 1957 Weiss, 1971 Williams, 1966

List of plants tolerant of arid or semi-arid - Part 75

24B, *Rosmarinus officinalis* L

{Rosemary)

Mediterranean region.

A perennial herb (of up to

2 m in height), which grows wild on the dry rocky hills in the Mediterranean region and is cultivated in e.g.

N. Africa and Spain. The herb iswidely used in flavouring foods land teas) and the derived essential oil is used in perfumery, in soaps, in cosmetics and to some extent medicinally and in liniments.

The leaves and upper parts of the plant yield, on steam distillation, 1—2% volatile oil I oil ol rosemary), which contains varying amounts ol Cr-pinene, 'verbenone' (the 4 keto deriv. of Q-pinene), camphor, borneol and 'euca-lyptol' (1, 8-cineole). The leaves also contain as a major constituent, (0.7%), carnosic acid, a diterpene cgrbo*y!iC acid which contains an aromatic {catechol) ring and which as a result has antioxidant activity. The leaves also contain several triterpenes and a flavone (but the alleged alkaloid rosmaricine, also reported in the leaves, has been shown to be an artefact).

Composition of the volatile (essential) oil very variable with geographical origin land to some extent season): e.g. samples from Corsica and Algeria have been reported (19731 to contain (bv 9.I.e.):

26-34%, 22-37%. 2-8%, trace—6%, end trace, respectively, of the five terpenes noted left — whereas samples from Tunisia gave corresponding figures of: 9—13%, trace—6%, 8-24%. 7-8%, and 35—50% (part of the variation seen in commercial oils may well be due to non-standardised production methods having been used — a problem in its own right which would need resolving before this oil could become commercial).

Abdel Haafezera/., 1966 Brieskorn and Domling, 1969 Brieskom and Michel, 1968 Brieskorn and ZweyiOhn. 1970 Butterfield and Pickthall, 1958 CSIR India, 1972 Granger et a/., 1970 Granger *et al.,* 1973 Ostric-Mat ijasevic, 1963 Uphof, 1968 Wenkerter^., 1966

249, *Rumex hymenosepalus* Torr. {Canaigre, raiz del India, wild rhubarb, American red ginsengl SW. USA, Mexico.

A perennial herb with tuberous roots which contain 'over 25%' tannin (improved strains yield '35—42%'); the roots are used by the local American Indians as a source of tanning agent (and the extracted tannin was exported to Europe in the late 19th century); also as a source of a yellow dye used for dyeing wool; and medicinally. Leaf-stal ks sometimes used for pies instead of rhubarb; leaves eaten as greens. Occasionally cultivated.

Can be grown as an annual crop for use as a source of tanning agent; adaptable to mechanical propagation □nd harvesting; the tannin is said to have excellent properties and the plant to be one of the most promising potential sources of tannins in the USA, Vield: 1,000 lbs tannin/acre (1,140 kg/ha) and 'promising[1] for sole leather; and may find use as a viscosity regulator for oil well drilling. Chrysophanic acid and physcion, both 1,8-dihydroxyanthraquinone derivatives, isolated (**1,2% and 0.3% respectively dry wt.) from the tubers (in 1955 — and despite conflicting reports, the related compound emodin since confirmed present). In addition crude isolates showing anti-tumour activity have been isolated from the roots and tubers (flavonoid derivatives). The roots also contain 20—30% starch and 9—13% sugars and the possibility of fermenting these constituents to alcohol, for fuel use, has also been mooted.**

Was research in the USA in 1950s on breeding for higher yields and on better processing methods, but this has not resulted in notable development as yet. To obtain the yields quoted, the plant may need some irrigation. Judged (in 1959) that commercial development of the plant for tanning material was not practical at the market prices then current. Despite vernacular name, no ginseng-like components detected.

Arnon, 1972 Buchalter, 1969 Buchalterand Cole,1967 Cole and Buchalier, 1965 Ojisbertj, 1952a Griffin er *at.,* 1959 Hillis, 1955 Johnston, 1979 Krochmal *eta!.,* 1954 |_ui and Staba, 1980 Uphof, 1968

US Report to Congress, 1957

List of plants tolerant of arid or semi-arid - Part 76

250. *Sai&ota arhuscufa* Pallas; syn. S. *richteri* Karel ex Moq.

Maritime and salt steppes of the USSR, Iran.

251, *Salsota kali* L. var, *ruthenics* (lljin) Sod;

syn. S. *pestifwa* A, Nels.,

S. *tenoifotm* Tsusch

(Russian thistle, tumbleweed, prickly saltwort, glasswort)

Widespread in drier areas of S. USSR and W USA.

252. *Satvadora persica* L,*

(Salt bush, mustard tree, toothbrush tree)

Middle East, tropical Africa, India, Sri Lanka.

The closely similar shrub (CSIR India, 1972) *Salvadora oleoides* also has oil-yielding seeds 145%) containing substituted ureas; again the fat makes a good soap and is a potential industrial substitute for coconut oil in this respect. The oilcake (30% protein, dry wt. basis) rs used commercially for feed.

List of plants tolerant of arid or semi-arid - Part 77

Plant is mentioned for its medicinal properties in the pharmacopoeia of the USSR. Grows extensively in semi-shifting sands.

A salt-tolerant, drought-resistant fleshy plant, the young shoots of which are occasionally used as a vegetable or in salad. Major use has been as a forage during times of scarcity of more usual grazing (e.g. in the 1930s drought of W. USA).

A salt-tolerant shrub to small tree which coppices well (for sticks and fuel) and if used to make shelter belts, Shoots eater* as salad and used as camel fodder. Fruits and the root bark are locally used medicinally and the seed fat is used for candles. The ash from the plant is high in salts, the crude solid being known as kegr.

Contains a group of isoquinoiine alkaloids — salsoline, salsolidine and salsamine — said to be capable of reducing blood pressure and similar in composition to those of Cactaceae. The plant is also useful for reinforcing shifting sands for their subsequent afforestation. As with the following entry, the plant accumulates high concentrations of salts and its ash could therefore be used as a source of these.

Good silage can be prepared from sal so la. which is equivalent to alfalfa in protein and fat content and superior in carbohydrate: fibre ratio. Will yield 6 tonnes dry matter/ ha p.a. with 240 mm rain and no fertilizer. Plant has very high salts content (especially potassium, ash contains up to 30% K_aOI and will reduce salinity of the soil in which it is growing. The sun-dried plant material has a heat content of 'Vi 15 megajoules/kg and, it has been suggested, would make a useful fuel for local use (domestic heating/cooking or local small-scale industries I after pelletising or pyrolysis to *a* crude liquid hydrocarbon fuel.

Seeds contain 35—45% oil with sap, val., 245—247; iod. val. around 6 {only). Unsap. fraction, 0.9%; sp. gr. {at 1^0, 0.8669, The oil tends to have a disagreeable odour but this vanishes on purification; it is inedible — due to the presence of various substituted dibenzylureas — but its fatty acid composition (lauric, 20%; my ristic, 55%; palmitic, 20%; oleic, 5%) is excellent for making soap? and it makes a good substitute for coconut oil and is a potential industrial substitute. The roots contain ^-sitosterol, m-methoxybenzoic acid, unidentified alkaloids and a substituted urea. The wood from the plant is white, easy to work and takes a good polish,

The alkaloids' medicinal properties may be of local use but are by no means unique — and all three have since been obtained by synthesis, Not listed in British Pharmacopoeia nor in Martindale.

A pest of agriculture in N, America where it is an aggressive and invasive weed of the ahd/semi-arid western states (especially on over-grazed or abandoned land). Has not been tried as a cultivated forage crop partly for this reason (in addition is prickly when dry, possibly making it unacceptable — except in times of scarcity). May be problem with high oxalic acid levels.

The plant is prone to attack by various beetle larvae and fungi. The root bark is acrid and vesicant. The wood makes a poor fuel.

Kametani and Okawara, 1977 Martindale, 1977 Paris and Dillemann, I960 Petrov, 1972 Proskurnina, 1958 Rossiiski, 1945 Teiteltfta/., 1974 Zaitschek, 1953

CSIR India, 1972

PonaJdson and Goering, 1940

Fowler and Hagerman, 1979

JJS'. 1980

Meinel *et at.,* 1930

UN,1977

Uphof, 196S

Willis and Shaw, 1973

Ayensu. 1979 Coursey, 1964 CSIR India. 1972 Khan *etai.,* 1072 Mensier, 1957 Ray *et aL,* 1975 Uphof. 1968 Sen and Bansal, 1979 Sen and Chawan, 1969
253 *Salvia officinalis* L.

(Common sage, garden sage)

Mediterranean region (but CLI **Itivated widely on small scale as a herb).**

254. *Sarcobatus vsrmicutatus* (Hook.) Torr.

(Greasewood bush, common or Mexican greasewood, chicol SW. USA and adjacent areas of Mexico.

Small shrub cultivated as kitchen herb used for flavouring foods: essential oil used in medicine (e.g. a; a vermifuge against ascaris) and flavouring, and also in perfumes, deodorants and insecticides. Leaves used as infusion — 'sage tea' (which is also said to have various medicinal, especially soothing, properties). Leaves also used in 'green cheese'. Dried leaves used as carminative, etc.

Nordihydroguaiaretic acid — an effective antioxidant for butter and fats - used to be extracted from leaves and twigs on a large scale for incorporation in foods.

Can be grown from seeds or cuttings, but seeds do not germinate well. Produces better quality flavour components on clay-loam soil; adapted to cotton-growing regions of S. USA. Herb also contains pentosans, a bitter principle resembling marrubiin, resins, tannins (3—7% in the leaves, depending or origin), etc. The resin is low in ash (1.5%), soluble in alcohol (and various other organic solvents), and is rich in catechol-like lantioxidant) components. Essential oil yield is 2.6% of dried wt, of leaf, and consists mainly of thujone (45—50%: the higher the better, being the major determinant of the oil's quality), linaly! acetate (10—15%l, Or and 0-pinenes (total 5—10%), and borneol and camphor (7—8% each). Leaves also contain carncsic acid, which is an antioxidant *(tee* entry no. 248). The Sterol (jS-sitOStercl) find tritflrpene (ursolic and oleanolic acids) content increases with plant maturity and is highest in leaves (0,25%, 0.13%, 0.08% dry wt, respectively). The leaves also contain a group of eight flavones (partly free and partly as glycosides based on genkwarijn]. The seeds contain a drying oil; fatty acid composition: oleic, 14%; linoleic, 29%; linolenic, 35%; sats., 12%,

Possible source of shellac.

Gave good quality essential oil when grown at Jammu in N. plains of India but quality said to suffer when plant is grown in particularly hot and dry climates.

Use of NDGA as an antioxidant in foods has recently been curtailed following toxicity studies: *see* entry no, 188. The foliage is high in oxalates so although it is sometimes used as a feed in semi-arid areas, undesirable to use to excess.

Arnon, 1972

Brieskorn and Biechele, 1971 Brieskorn and Domling, 1969 CSIR India, 1972 Duquesnois, 1972 Hanson and Hocking, 1957 IWurko *et al.,* 1974 Nicholas. 1961 Uphof, 1963 Walther, 1958

Clawson, 1934

Colton, 1943

Cruse, 1949

Fleming ef a/., 1928

Sampson and Malmsten, 1935

Uphof, 1968

List of plants tolerant of arid or semi-arid - Part 78

Name(s)/Distribution	Current/past uses	Potential	Constraints	Citation data
255. *Scaevola plumieri* (L.) Vahl Along tropical coastlines and beaches.	A wild shrub found in arid lands (and presumably also salt-tolerant). Pith is squeezed flat to make rice paper. Other *Scaevola* spp. (e.g. *S. serucea* Vahl, syn. *S. koenigii* Vahl: CSIR India, 1972; Uphof, 1968) yield a hard wood which is resistant to salt water and is used in boat building.	Seed contains 66.7% oil, 19.2% protein.		Jones and Barclay, 1972 Willis and Shaw, 1973
256. *Scorzonera tau-saghyz* Lips. and Bosse (Black root, sweet root) On the Kara-Tau plateau of S. USSR.	Grown in the USSR as a source of rubber (which is in the root). The plant is perennial and may continue storing rubber for many years.	The plant can be cultivated in very different climates – easily propagated by seed or root cuttings. Sometimes up to 40% w/w of rubber can be obtained from the roots (probably the highest concentration in any plant) and it is usually of excellent quality.	Found at elevations of 500–1,100 m, with a short summer and where annual rainfall is 350 mm (but coupled with a long cold winter: the plant may need more water in a uniformly hot climate). Difficult to establish. Entire plant must be ploughed up since nearly all the rubber is in the roots, very little is in the aerial parts. Plant may take up to 5 years to accumulate maximum rubber content – much longer than its nearest competitor (*Taraxacum kok-saghyz*: which see) but which however has a lower maximal rubber content.	Anon, 1932 Arnon, 1972 Kosurukow, 1935 Polhamus, 1962 Uphof, 1968

List of plants tolerant of arid or semi-arid - Part 79

Citation data

Potential

Constraints

257. *Sesamum indicum* L.; **syn. *Sesamum orientate* L.**

(Sesame, bene, benniseed, gingili fgin-gelIV). simsim)

Widely distributed in tropical and sub-tropical areas.

The seeds are used in bread and con feet inner v. However, the major outlet is as the source of a high-quality, colourless, unsaturated oil used as *a* cooking or salad oil and in shortenings. (It is also added to other oils tc prevent their oxidative deterioration.) But it also has various non-food uses based on the combination of it being a free-running **Oii** and yet reasonably stable to oxidation, due to the presence of **The** natural antioxidant, sesamol (3, 4-methy lenedioxy-phenol); e.g. as a solvent for fat-soluble medicaments for injection, in the preparation of ointments and cosmetics, as *a* base for perfumes, to oil tanned hides, and to make soap. The oil also contains (0.5—1.0% and 0.3—0.5% w/w respectively) sesamin and sesamolin fboth C_2a compounds related to sesamol) which act as synergists to **(i.e.** boost **the activity** of) the insecticides pyrethrum and rotenone. The oilcake is used as cattle feed or fertiliier.

Seed yields range from 80 kg/ha to 750 kg/ha (and to

2,000 kg/ha with modern cultural practices including irrigation). Oil content, 40—58%, The oil is stable due to the antioxidant constituent. The oil-extraction rate varies from 35—50% oil according to method. Fatty acid composition: palmitic, 7—9%; stearic, 4—5%; oleic,

37 — 50%; I inoleie, 37—47%; sp. gr. (at 25° Cl, 0.918—0.926; refractive index, 1.472-1.474; iod. val,, 104-118; sap. val., 187—1 S3; unsap. matter, 1.5—2.5% (of which sterols, 0.3-0.5%).

Not suitable for altitude: above 1,250 m. Intolerant **of** acid soils. Seeds germinate slowly (rate can be accelerated by growth **Substances!;** temperature of 25 -27^{r}C best for rapid germination and for the plant's subsequent development. Plant requires 200—

Amon, 1972

Beroza. 1954

CSIR India, 1972

El Baradi, 1972

Godin and Spensley, 1971

Lyon, 1972

Paroda, 1979

Tribe, 1967

Weiss, 1971

Williams. 1966

800 mm rain p.a. (400 mm said to be adequate for dry land farming in the Mediterranean region). If grown in desert area:, may require some irrigation during the growing season. Sensitive to frosts. Dehiscent varieties present harvesting problems. Subject to attack by various pests and diseases. A dry period is required for ripening but temperatures above40 C harmful. The oil's stability may be seriously reduced (due to the removal of the sesamol] by purification procedures such as steam distillation or deodorisation (sesamol volatile!. Sesamin and sesamofin have largely be«n replaced as synergists by the semi-synthetic analogue, piperonyi butoxide.

List of plants tolerant of arid or semi-arid - Part 80

258. *Sirnmondsia chinensis* I Link) Schneider;

svn. *S. caiifornica* Nutt.

(Jojoba, goat nut, pignut I,

5W. USA and adjacent areas of N„ Mexico, especially the Sonora Desert,

Traditionally, the local **Indians** have hand-harvested wild stands to make various beverages, etc. from the seeds and to express the Oil for medicinal **uses.**

A shrub commonly 0.5—2 m in height, but occasionally 3 m, which grows wild on dry, gravelly, well-drained slopes, from sea level to 1,200 m. tolerates air temperatures of up to 45°C and, when mature, tolerates -frosts to -9°C. Has a system of deep tap roots and can survive, and apparently even produce some seed, on 100 mm rain p.a. I though run-off may concentrate this; generally needs more For reliable seed production) and survives complete drought for up to a year by leaf-shedding. Lives for 100 + years; salt-tolerant Iso can use salty irrigation water to help establish plantations! and suffers from no severe pests in the areas so far tried. The seed yields (50%), by normal mechanical expression,an almost colourless, odourless oil with f.p., 10-7"C;b.p. (under Nz), 398°C; smoke p., 195'C; iod. val., 82; sp. gr„ lat 25°C) 0.863. It is unchanged by prolonged heating and requires no refining before use. It is unusual - possibly unique — for *e* seed

oil in that it is r>ot a glyceride 'fat' but a liquid wax consisting almost entirely (97%) of a mixture of wax esters (esters of long-chain fatty acids and similar alcohols), the major constituent fatty acids,all monounsaturated, being: Cis (i.e.oieicl, 10%; C_{2}o, 71 *%; C_{2}2.* 14%;C_{2}4, 1%;and the alcohols, also mo nounsaturated: C20, 44%; C22, 45%; C24, 9%. Jojoba oil thus closely resembles the industrially important product sperm whale Oil **(in detail, it is more homogeneous, of higher molecular weight anct lacks sperm whale oil's glyceride content — and, advantageously, its fishy odourl, whose use has recently been partly or completely banned by various governments as a conservation measure. Th is has led to widespread interest in jojoba with extensive literature, and a biennial international conference and periodical *[Jojoba Happenings,* University ot Arizona) devoted entirely to it. Extensive research seems to indicate that jojoba oil could replace sperm whale oil in many of its uses — especially in lubricants, either as such or after sulphurisation, where its stability to heat** and **chemical degradation, and its metaf-wetting capacity, enables it to be used at high temperatures** and **very high pressures. It may also be able to replace, at least in part, the sperm whale oil traditionally used to oil and soften leathers. The many other** uses **mooted for it once, or** if,

Requires 400—500 mm rain p.a. for a worthwhile crop; must be mainly winter/spring rain (claims of good yields on much jess probably due to runoff effectsl. Even then, yield very variable in wild stands and still too low to be viable even when cultivated; end although plant selection/breeding experiments are proceeding, still too early to be sure that a reliable and sufficient Isay 2,5 tonnes oil/ha from mature (>8-year| plants) yield can be obtained. With wild plants, yield continues to rise as moisture input is increased from the 400/500 mm level to 1,300 mm (which implies the need for irrigation or the construction of run-off catchment hol(ows). Tendency for the current experimental plantations barely to be in even the semt-arid category. Jojoba is naturally dioecious (separate male and female plants) with wind pollination, so that plantation workers must be able to recognise the male seedlings and insert them thinly and evenly throughout the otherwise female plantation (typically at 1 in 10), wasting the rest (current plant-select ion work may eventually remove this difficulty). Five year wait from planting seedling to worthwhile seed production

Anon, 1979b Anon, 1980a Anon, 1980b Aronson and Zur, 1982 Bell *etai..* 1977 Brooks, 1978

Clarke and Yermanos, 1980 Oeyine and Johnson, 1978 Elliger *et al.,* 1975 Fink and Ehrler, 1979 Foster and Wright, 1980 Geigert *etal.,* 1980 Hogan, 1979 Johnson. 1977 Letan, 1975 Miwa era/., 1974 National Academy of Sciences, 1975

Prabhudesai and Viswanathan, 1978 Princen, 1979 Schechter in Davis, 1978a Sherhrooke, 1978 Simpson and Miwa, 1977 Spener, 1979 Walters *eta),,* 1979 Wisniak, 1977 Yermanos, 1978 Yermanos *etat.,* 1979

List of plants tolerant of arid or semi-arid - Part 81

Name(s)/Distribution	Current/past uses	Potential	Constraints	Citation data
Simmondsia chinensis (cont'd)		it becomes commercially available, include use as a source of the rubbery material known as a 'factice' used in the manufacture of linoleum, printing ink, paints and varnishes), of long-chain unsaturated fatty acids and alcohols (which could be derivatised at the double bond to make plasticisers, etc.), as an inert solvent for orally administered drugs, as an antifoam agent in antibiotic manufacture, in cosmetics, etc. On hydrogenation, jojoba oil gives a solid (m.p. 67°C), hard white wax (almost as hard as carnauba) for which many traditional uses could be envisaged — such as in polishes, carbon paper, smokeless candles, etc. It is also fully miscible with polyethylene to which it imparts additional, and possibly useful, hardness. The oilcake contains 30/35% protein but also an appetite-depressant, simmondsin. This led to starvation of trial animals fed it at a level greater than 10% in a mixed feed (though desert rodents eat the whole seeds with no apparent ill effect — perhaps through adaptation). However, a method of detoxifying by prolonged treatment with ammonia has been reported.	and a further 3—4 years until a steady commercial level is reached. Shrubs damaged by temperatures below −9°C (seedlings, −4°C). Considered that except in regions where very cheap labour available for hand-harvesting, mechanical harvesting will be necessary and no method of so doing has yet been devised; tendency for rodents to take fallen seeds so may need to harvest continuously as they ripen. Total market for the oil likely to remain relatively small and specialist, mainly as a sperm whale oil substitute and in the cosmetic and pharmaceutical industries. The demand for the wax is likely to be small as there is a surplus of carnauba, etc. waxes (which, in addition, do not need hydrogenation first). Current demand for sperm whale oil is much down on the mid-1960s figure of 150,000 tonnes p.a. and could be satisfied, at 2.5 tonnes oil/ha, by only 10,000 ha of mature jojoba (though more, in the event of its other suggested uses leading to a substantial demand). Also, *Limanthes alba* and *Moringa oleifera* (entry nos. 194 and 203) may compete as partial sperm whale oil substitutes; and, more likely, substitutes manufactured from common glyceride oils (by hydrolysis,	

List of plants tolerant of arid or semi-arid - Part 82

Name(s)/Distribution	Current/past uses	Potential	Constraints	Citation data
Simmondisia chinensis (contd)			reduction of half the acids to alcohols, and coupling) may become established before jojoba oil can be produced in commercial quantities. The oilcake-detoxification procedure so far reported requires a 30-day contact time to be effective, and coupled with the cost of the ammonia, is likely to make the material uncompetitive, except where there is little alternative. Introduction into other arid regions restricted by soil type and the need for winter/spring rains; browsing animals (and local insects) would be a problem at the seedling stage; an area in western Saudi Arabia has been mooted. The effect of differing daylight lengths on growth, simmondsin content, etc. currently being studied.	
259. *Smirnowia turkestana* Bunge USSR. Widespread in C. Asia.	Grows to 1 m in height; used in treatment of hypertension and relieving blood vessel spasms.	Two alkaloids of unknown structure (smirnovinine and spherophysine) isolated.		Petrov, 1972 Ryabinin and Il'ina, 1951
260. *Solanum carolinense* L. (Carolina horse nettle) N. America	Air-dried ripe fruits used as sedative and anti-spasmodic.	Steroid alkaloids (solasodine etc.) found; also (from the roots) solamine (an aliphatic base), the insecticide anabasine, and a carbamate with a structure resembling some of the synthetic carbamate insecticides.	Anabasine of minor importance: *see* entry no. 31.	Arnon, 1972 Evans and Somanabandhu, 1977 Uphof, 1968

List of plants tolerant of arid or semi-arid - Part 83

261. *Sofanurrt incamjm* L.;

Syn. *mnelonijena* L. war, *incanutn* IL.I Kunt;e I Asirid)

E. Africa, SE. Asia.

262 *Solatium surattense* Burm. f. syn. S. *xanlhocarptim* Schard. & Wend I.

Widely in the tropics Of the Old World.

263. *So l* ***id ago canadcnsts*** (Canada goldenrod)

Eastern N. Ainerita and the W. deserts; also in India (as an **Ornamental),**

A woody herb. Fruit and leaves used w'dely as drugs in e.g, Kenya, both topically and orally (see 'Constraints' for the danger of so doing); seeds are used for curdling milk. Root used as horse medicine.

Used medicinally in Hindu India against fever and chest complaints; seeds used as an expectorant,

A perennial herb: the seeds were eaten by the local Indian tribes An emergency food plant, and source of oil

— goldenrod oil.

The plant is easy to cultivate, yielding 60 - 70 fruits per plant and can replace 5. *khasianum* as □ source of glyco-alkaloids. Alkaloids found in all parts of plant but mostly in the fruits, especially solasodme and its glycoside derivative, sola&onme. Diosgenin and yamogenin (optical isomers, al C251 also present. These four compounds can all be converted by acid treatment into precursors for the steroid industry: see next entry. A high-alkaloid content race occurs in S. India,

Fruit contains 20.7% *wlw* seeds, and seeds 19% semidrying oil containing 43% oleic, 36% linoleic, 5% palmitic and 10% stearic acids; and with sp. gr, (at 27° Cl 0,924; sap, val., 182; iod. val124; unsap. fraction, 1—1.5%.

Fruits contain 1.1 % steriodal alkaloids of the solasodine (set previous entry) type*; also diosgenin. Relatively large amounts Of (3-sitOSterOl also thought to be present. Carpesterol, an unusual and potential ly useful C3Q sterol with C=0 at Ce, C=C at C7-C8, -OH et *C22,* and present as a C3- beruoate, isolated Various coumarins and quercetin (flavone) also isolated. Whole-plant extract shows anti-viral and anti-tumour activity.

The whole plant contains about 4% latex (other *Sotidagc* spp have occasionally been proposed as an emergency source Of rubber). Steam distillation of the aerial parts yields0,6% of a pale yellow fragrant oil, Canadian goldenrod oil, consisting mainly of terpenes. The aerial parts also contain a series of flavones (rutin, campherol, quercitin and isorhamnetm! and a f lavone glycoside, isoquercitrin. Roots contain the multi-functional Ifuran ring, conjudg. ene-one, — OH) diterpene solidagenone (1 ,2%) and two related spiro-ethers {total 2%5;also a series of terpenes ((J-caryophyllene *etc:* according to i.r.), hydrocarbon waxes and myrieyl alcohol (a C30 wax alcohol). The seeds yield 30% of a semi-drying oil with iod. val. 140,and containing 62% linoleic and 32% oleic acids plus 3% of a keto- and ***2%*** of a hydroxy-acid. Extracts of leaves (and fess so, flowers} show hypotensive activity.

Fruit found to contain dimethy Initrosam ine, a potent carcinogen. Market for steroid precursors of the kind mentioned here is now poor: *see* entry no. 11 1. In addition, several of the species even in this compilation also yield steroid precursors (e.g. entries 11 1, 1 70, 262).

Demand for steroid precursors poor: *see* previous entry for the specie^. Little demand for the coumarins also present — hence steroids industry will not benefit in reducing manufacturing costs by exploiting other constituents.

Rutin was once considered to have vitamin activity but this is now largely discounted: *see* entry no, 208

Ali *eta/.,* 1967

Ammal and Viswanathan, 1974 Baquar and Tasnif, 1967 Coppen, 1980 CSIR India, 1972 Du Plessis er *al.,* 1969 Schoental, 1969 Segal *et al.,* 1977

Arnon, 1972 Ayensu, 1979 Beisler and Sato, 1971 Bhatnagar *era!.,* 1961 Dubey and Gupta, 1978 Gupta and Dutt, 1936 Heble *et at.,* 1968 Mensier, 1957 Paul *et a!.,* 1958 Tupksri *et al.,* 1972 Uphof, 1968

Anthonsen er *al.,* 1969 Batyukand Kol tsova. 1968, 1969 Buehrer and Benson, 1945 CSIR India, 1972 Earle ef *3!.,* 1960b Krepinskyand Herout, 1962 Krochmal er *at.,* 1954 Ft0Ci et *at.,* 1979

Such compounds are common in *Solanum* spp and e.g. the fruits of 5, intficuw, a forest shrub (and so non-arid tolerant?) from the hotter parts of India ICSIR India, 1972), contain 1,8% of these compounds, but the same constraints apply (although as compared with obtaining steroid precursors from slow-growing *Dioscorea* tubers, solanum fruits appear quickly].

List of plants tolerant of arid or semi-arid - Part 84

264. *StiUingia sylvatica* L.

(Queen'sdelight, queer's root, yaw root)

N. America {e.g. in the SW. deserts)

265, *Stifia tffrtacissima* L*; syn. *Mscrochtoa tenacisslma* (L.)

Kg nth

(Esparto grass, a I Fa grass, helfa grass)

N. Africa.

A herbaceous perennial; grows best in dry sandy soils; up to 1 —1,5 m tall. Dried root has been used medicinally — as an emetic, cathartic, laxative, d jiretic and 'tonic' (was men' tioned in US Pharmacopoeia and is noted in the Merck index of chemicals and drugs for 19761.

A perennial grass which takes

12 years to mature. An important source of paper-making material in the Mediterranean region; also used for ropes, sails, mats, etc. Some is exported for pulp. Cattle 9raie On natural pOpu lations The wax which can also be obtained is used in carbon paper, polishes and leather finishes.

Seed contain 30—33% light yellow oil; sp. gr., (at 25° C) 0.926; r.L, 1.4833; sap. val,, 189; iod. val., 190; acetyl val., 37,5; unsap, fraction about G.75% Approximate fatty acid composition: oleic. 18%; linoleic, 25%; linolenic, 48% (remainder are saturateds). Should make a good drying oil suitable for paints and varnishes, and allied products requiring such. The oil dries in 4—6 h when spread out in the air. Root contains an acrid resin Isylvacroll, an acrid oil, a glucoside, 3—4% of volatile oil, and 10—12% tannin.

Grows wild in near-desert areas (rainfall 150 mm/year). Green plant yields 40—42% cellulose. The pulp is suitable for printing, writing and wrapping papers, Research programme in Tunisia for improvement of quality and development of simple harvesting machines. Esparto wax occurs as a coating on the grass and is released as a byproduct during paper manufacture; yield up to 5%; a hard, brittle, non-tBcky brownish wax, m,p. 78°C, which on melting then solidifying gives a very smooth surface. It contains 65-70% of the hydrocarbon C3iHe4, has an acid value of around 30; sap. vat., 63—69; iod. va!., 8-16. tt is a good substitute for carnauba wax — and superior in the sense that it contracts less on solidifying and gives softer films. About 500 tons of purs wax per annum were being produced by ^{an} Italian firm in the early 1940s. There is 3 patent for production of activated carbon from the residue resulting from the alkali digestion. Residue from wax purification forms excellent filler for moulded plastics.

Member of the Euphorbiaceae Adolf and Hecker, 1980

and so handling may be hazardous *{see* footnote to entry no. 1261; the root resin is known to be toxic and very irritant.

Organic solvents (expensive/ inflammable) required to extract end purify the wax. Generally poor market for waxes *isee* comments under entry no. 258) though may possibly fulfil a local need.

Not so readily miscible with fatty and other oils as carnauba. Plant breeding experiments, by seed or vegetatively, have not been encouraging.

Anon, 1930a Batterson and Potts, 1951 Krochmal *et al.,* 1954 Mensier, 1957 Uphof, 1968

Anon, 1942a Anon, 1951a Anon, 1978 Arnon, 1972 Bennett, 1975 Bui-Xuan-Nhusn, 1971 Farnell, 1934 Isenberg, 1956 Soler and Guiman, 1954 Uphof, 1968 Winkler. 1968

List of plants tolerant of arid or semi-arid - Part 85

[1] *See* also *Lygeum spartum*

Potential Constraints

266. *Styrax offtcinatis* L

{Officinal styrax, styrax ireet

S- Europe, Asia Minor (Turkey, Greece, Cyprus, Crete).

A small shrub; the resin (storaxl is used in pharmacy, cosmetics, perfumery, etc. and as a source of incense. Seed powder is used as an insecticide, in fish baits and as a fish poison.

Grows up to an altitude of 700 m_ Produces 1 - 6 kg (small to large bushesl fruits; oil content of seed, 50%, protein, 16.5%. The oil is viscous, slightly yellow, tasteless; can be used in soap; its low iodine value (72) prevents use in dye industry. Fatty acid composition: oleic, 51.*5%;* linolenic, 26.6%; palmitic, 11.6%; A^9-eicosenoie (C20), 7.1%; stearic etc. 2%; leaf extract showed (weak) antitumour activity: analysis showed presence of paraffinic (waxy) hydrocarbons, derived long-chain ketones and alcohols, and ^-sitosterol. A saponin with exceptionally strong foaming action and haemolytic activity isolated from pericarp, A series of glycosides isolated from seeds which yield, on acid hydrolysis, the substituted benzofuran egonol and related compounds.

Diapoulis, 1952

Jones and Barclay, 1972

Segal *et at.,* 1964

Segal *et at.,* 1967

Ufubelen, 1976

Ulubelen and Gbren, 1973

Vardar and Oflas, 1973

267. *Tamarix gatfica* L.' (Tamarisk, salt cedar, French tamarisk}

Mediterranean region, introduced into the 5W, USA.

A shrub or small tree; in wadis and other areas likely to contain residual moisture.

The wood has been suggested as a source of fuel, fence posts, wood pulp and to make furniture. Plant contains active principle which cO/nbSts liver damage. *Tarrtafrx* spp. noted as potential firewood sources by the National Academy of Sciences (1980),

Has a relatively large water requirement and has extensive tap roots to supply it, but in so doing denudes the immediate area of moisture to the detriment of other plants. A pest in areas where some form of irrigation is practised, as it colonises, and draws water from, irrigation channels and stream beds.

Arnon, 1972 Ayersu, 1979 Senson and Darrow, 1944 Duisberg, 1952a, b □uisberg and Hay, 1971

A very simila' plant, salt-tolerant and 'able to flourish with scanty rainfall end extremes of temperature', occurs in Indie and used also to be described as *T. ga/lfca;* but more recently has been considered a distinct species — *T. trouph* or *T. indica* ICSIR India, 1976a); it contains the phenol ellagic acid (0.1 % in the roots) and is used widely in local medicine, for making wooden implements, thatching and firewood (ibid; Israili er *at.,* 1965).

List of plants tolerant of arid or semi-arid - Part 86

268. *Taraxacum kok-saghyz* Rodin (Kok-saghy?, Russian dandelionl On the KaraTau plateau of S. USSR.

269. *Tecoma stans* 11— l Juss; syn. *Stenofobium stans* Seem,

***Bigncr>ia stans* L.,**

***Tecoma mollis* Kunth**

(Yellow elder, trumpet bush, yellow bells)

N. and S. America, Cuba, Mexico naturalised in India and W. Africa.

List of plants tolerant of arid or semi-arid - Part 87

Planted in the USSR durir»g World War II, and in the USA from seed supplied bv the USSR, as a source of letex (in roots!; planting since discon* tinued in the USA. A perennial herb.

Shrub or small tree; grown as a hedge plant. In India grows wild in waste, drv places. The roots are used in Mexico for making beer and also medicinally (to control diabetes).

Experimental work in Sweden and Spain on high-yielding strains were successful; yield of 130 lb of rubber/acre (150 kg/hs) obtained. As compared with its nearest competitor, (jef entry no, 256|, kok-saghyz is easier to establish and produces a worthwhile crop of rubber in a single season (but *see* right). Average rubber content of roots, 6%. Does not generally require a high concentration of fertilizer* in peat soil.

The plant contains almost 4% latex. The roots are considered a powerful diuretic, vermifuge, tonic. Seeds have a bitter taste (alkaloids) and contain (23%) an oil with iod. val., 209 (hence a potential drying oil); fatty acid composition: palmitic, G%; stearic, 3%; C18 with One C=C (? oleic), 7%; with two (7 iinoleic), 24%; with three (? linolenicl, 41%; with four 4a new and unusual structure wirh *C^C* at positions 3, 9, 12,151,19%. The plant was early shown to contain triterpenes, hydrocarbons, resins and alkaloids. Of these, the latter now known to consist of a series of six or more Ci 1 (pyrindane) alkaloids based on the skytenthine skeleton, che major one being tecomine (tecomanineh Tecomine shows high hypogly caemic activity (and low toxicity) in experimental animals, so confirming the plant's traditional use as en anti-diabetes drug by the Mexican Indians. An indole oxidase (enzyme) has been isolated from the leaves; the dried fruits contain 0.06% sterols of which half is j3-sitosterol. The flower petals contain {126 p.p.m, fresh wt.) a mixture of ^-carotene (pro-vitamin A) and zeaxanthin, 1:6.

Adapted to a short summer growing season; found at high altitudes where there is a high diurnal variation in temperature. Seeds require high moisture soil content for germination land pre-treatment, according to trials in Australia). Soils rich in organic matter give best production, produces a relatively low {especially as compared with entry no. 256) concentration of rubber. The rubber is in the roots so the entire plant has to be harvested,

Tecomine is unstable to air (especially at alkaline pH) making its clinical use possibly difficult (though this is countered by anti-Oxidants).

It is not mentioned as a recognised drug in Martindale's p harm acop o e i a. The ca roten e is present in too small a concentration to be really useful {and it; identity was not proven unequivocally).

Anon, 1944a Arnon, 1972 Garkavyi, 1935 Polhamus, 1962

Bianco *era!.,* **1980 CSIR India, 1976a Dickinson and Jones, 1969 Hammouda eta/., 1963 Hammoudaand Khalfallah, 1971 Harrtmouda and Le Men, 1963 Hammouda and Motawi, 1959 Hopkins and Chisholm, 1965 Jones *etal.,* 1963 Jones ef *si.,* 1971 Krochmal *et a!.,* 1954 Maheshwari and Banerjee, 1970 Martindale, 1977 Nair and Vaidyanathan, 1964 Taha, 1954 Uphof, 1968**

270. *Tephrosia vogetii* Hook f.

{Fish poison bean)

Tropical Africa, naturalised in India,

[For *Testudindfia* Spp., see under *Dioscorea* spp.]

271. *Thymeiaea hirsute {*L.J Endl; s v n, *passerina h inn* fa L,

***Daphne gmdium* L.**

(SparrOw-wOrt, gnicfium, spurge flax, mitnar)

Mediterranean area (Egypt, Libya, etc.)

Shrub 2—4 m high; can thrive on very poor soils. Grown as a green manure and used to stupefy fish (still edible) and as an insecticide.

A shrub which grows abundantly in the Mediterranean coastal strip and desert. Crushed roots used in Sardinia to stupefy fish, powdered bark as an abortive. Leaf is ar anthelmintic, the powder a remedy for dermatitis, and the bark is used in treatment of wounds.

Seeds contain 13% oil; sap. val., 163; iod. val., 103. Seeds have high content of N material and no sugars. Main interest is the rotenoid content of the plant (rotenone and analogues — powerful natural insecticides, which are less toxic to warm-blooded animals than the synthetic organo-chlorine compounds like DDT and BHC(. concentrated in the leaves;content, 2—3% (dry wt. basis) in improved Strains in fresh leaves; although this is only that in the traditional rotenone sources

(viz. *Derr is* snd *Loncfrocarpus* sp, roots), the latter only yield after 2—3 years and one needs to harvest the whole plant, whereas 7", *voge/ii* **leaves can be gathered , if sufficient moisture, 6 months after sowing seed. Best yield obtained ('V 140 kg/tia) by gathering leaves just before the plant flowers. Although essentially an annual, it will regrow for a 2nd year's crop. Of all *Tephrosia* spp., *vogetii* contains the most rotenoids,**

Bark is a source of a strong fibre; possible use for textiles requires investigation, Described as a new paper-making source giving a high-quality pulp. Leaves contain 0.1 % of a crystalline reducing phenol, 'thymelol' (since shown to be a substituted coumarin, daphnoretin) and also a catechol-tannln. The lipids in the leaves consist of 3% fatty acids esters 464% sat. Cl4—C20 acids and 18% oleic, 11K linoleic, 7% linolenic) and \% unsap. material [paraffinic waxes (C27—C31) **and wax alcohols** *{C22 —* **C2al) and also ^-sitosterol Iplus a little campesterol). The plant also contains an essential oil and a kaempferol glycoside (tiliroside),**

Main doubt is to what extent this plant is truly arid (or even semi-arid (tolerant, Frequent irrigation was found to be necessary for young plants growing in experimental plots in the Indian plains (possibly less necessary for the 2nd year's growth). Rotenoid content varies widely in wild stands (some indications that content higher in relatively dry areas). Extraction method important: extensive pre-drying results in loss of rotenoids. Best to heat fresh leaves in acetone, this being better than the Soxhlet-axtraction equivalent. Seeds meed pre-treatment for good germination. Labour costs of raising annuals relatively high. Is susceptible to damage by browsing animals. The plant has become a difficult to-control weed in parts of fnd ia.

Poisonous to browsing animals (cattle and camels).

Barnes and Freyre, 1966a, b Barnes and Freyre, 1967 Barnes and Freyre, 1969 CSIR India, 1976a Gaskins *etaJ_*, 1972 Hagemann era/., 1972 Kapur era/., 1972 Martin and Cabaniilas, 1370 Mensier, T957 Tucakov, 1965 Uphof, 1968 White and Wolff, 1968

Boyko, 1954 Ismail, 1978 Lewin, 1953

National Paper Co. <and University of Tanta), Egypt; in Davis, 1978c Risk ef a/., 1974 Saleh *et a!.,* 1963 Saleh and Sarg, 1965 Uphof, 1968

List of plants tolerant of arid or semi-arid - Part 88

272. *Thymus capitatus* (1__> Hoffm.

& Link;

:yr *Cpridothymus capitatus* (L.| Reichb. f.

(Conehead thyme, thyme of Sicily, Origanuml

Mediterranean area.

A shrub which grows in arid and calcareous soils. Steam distillation of the aerial parts of the plant yields (1.5%) sn essential oil which has many medicinal uses both externally and internally (indigestive complaint; etc.) And is antiseptic. The oil is also used for scenting soaps and both oil and dried plant are used for flavouring foods (sea following entry I.

Constituents of the essential oil are cymerte and 75—80% of carvacrol. Carvacrol can be used for production of carvomenthol ester; which are used in cosmetics.

Composition of oit varies with locality.

Drar, 1954

□uisbergand Hay, 1971 Fayaud and Rivera, 1954 Rovesti, 1961 Rovesti, 1970 Uphof, 1968

273. *Thymus vulgaris* L. (Common thyme, garden thyme) Mediterranean area (e.g. Algeria,

S Spain, Morocco)

Steam distillation of the aerial parts of the plant yields 1—2% essential oil, a commercial product (from e.g. S. Spain) used widely in medicine as an antiseptic and disinfectant both externally and in oral preparations. Mentioned in various pharmacopoeias for its medicinal uses such as in mouth was ties; also as an antispasmodic, a carminative and in cough linctus. Also used for scenting soap and as a food flavouring (the dried plants themselves are also used for this).

Composition of 'thyme oil' varies somewhat with the species used (not always *T. vutgaris*\ but is usually rich in phenols {typically 50—60%|, especially thymol and carvacrol. The seeds yield (37%) an oil with iod- val.,

208 and Fatty acid composition: oleic, 18%: linoleic, 13%; linolenic, 62%; sat*., 3%. Hence potentially a very good drying oil. The plant also contains various triterpenes and flavores and the leaves are a good source of thiamine (vitamin B11.

Plants become woody and have to be replanted after 3—4 years. Composition of oil varies, depending on altitude at which plant is grown.

CSIR India, 1976a Duisberg and Hay, 1971 Earle er a/., 1960a Guenther, 1949 Kenning, 1952 Martindale, 1977

List of plants tolerant of arid or semi-arid - Part 89

274, *Trigonella foenum-graecu*n L.

IFenugreek, metha, helba)

Mediterranean (including N. Africa], India, Ethiopia and China.

275. *Turbina corymbosa* \ L.) Raf[1] syn. *tpomoea burman/ii* Choisy, *t. sic/if Of is* Choisy.

***Rivf& corymbose* (LJ Hall *.** (Ololruqup, piule, ye-rba de fa Virg§)

Mexico to S. America, cultivated m

E. Africa.

276. *Uryinea in&ica* Kutuh (Incl13n squil 11 I ndia,

An annual herb, cultivated N. Afr ica and I ndia las a winter crop), The leaves of the plant are used as a vegetable and as a livestock feed (e.g. in N. India where it is considered superior to, anti more drought resistant than, several other fodder legumes). The seeds are used as a food, spice and condiment and also medici naliy, as a demulcent and emollient, and in poultices. The essential oil is used in perfumery. Seed extract is used as a flavouring for ice cream etc. and powdered seed as

***3* dye.**

***A* woody vi ne, used as a source Of narcotics from ancient times. Seeds of the plant still used by Mexican Indians as a hallucinogenic drug; sold locally for such purposes.**

A small bulbous perennial found on the Indian plains and the dry lower slopes of the Himalayas; is cultivated for its medicinal uses.

Generally similar properties, actions and uses to *U. maritima,* and also appears in pharmacopoeias.

A leguminous plant so should help soil fertility, Seeds contain 28 - 39% crude protein, 6-8% fatty oil, 0.02% essential oil, a galactorrrannan mucilage (gum], the alkaloid trigonelline la nicotinic acid derivative) and ^1% diosgenin (and traces of other sapogenins). The leaves also contain the latter compounds and the plant has been seriously considered as a source of **sapogenins** for **the steroid industry (grows faster, and easier to hardest than *Dioscorea* tubers). The fatty oil has iod, val,, 115; sap. val., 130 and contains 1 794 sat, (C16-C22) fatty acids, 35% oleic, 34% linoleic and 14% linolenic. The mucilage is said to be as good as, or superior to, guar *{see* entry no. 97) and alginic acid as, respectively, a paper-si^e and swelling agent in pharmaceutical preparations.**

Analysis of seeds from Cuba: alkaloids 0.045% of fresh weight (some claim up to 0.07% in the kernel); 'lipids', 8% Al kaioids were found in the embryo but not in the seed coat. The ergot alkaloids ergine and isoergine, along with a series of related lysergic acid derivatives, occur variously in the seed, leaf and stem — but not the root, The seeds also contain a DNS-stimulant, turbicoryn (a glucoside). and 8% fatty oil.

In place of the alcohol-soluble carbohydrate content in *U- maritima,* this squill's bulb is rich in alcohol-insoluble mucilage which can be used in dilute aqueous solution as an adhesive and for siting cotton cloth. An aicoho! extract of the bulbs shows anti-cancer and hypoglycaemic activity.

Doubtful whether can be considered truly semi-arid tolerant- responds vigorously to irrigation and said to grow best with 20-60 ins (5001,500 mm) rain p.a. Use of diosgenin as steroid precursor has limitations - jfe entry no. 111 (though this plant has the advantages of being multi -purpose, providing gum and fodder as well as sapogenins, and quick-growing), The seed oil has an unpleasant odour (but this can be removed by washing with a mixture of methanol and petroleum ether).

Not listed by Arnon (19721 and probably only tolerant of semi-arid conditions. Also only of limited value lergot alkaloids are available, if needed, from ottier Sources and there is only a low percentage of oil present).

Said to prefer > 500 mm rain p.a. on a sandy soil. Drug hygroscopic (lee next entry), Has lower glycoside content than *U- mdritima* and is only used as a substitute when *U. maritima* is in short supply. Considerable variation in cardiotonic-glycoside content

Anon, 1956 Blunden *et* a/., 1975 CSIR India, 1976a Flaschentrager and Kalatzis, 1957 Gardener, 1982 Mensier, 1957 Reid and Meier, 1970 Shankaracharya and Natarajan, 1972

Shankaracharya era/, 1973 Singh and Mehra, 1970 UNESCO, 1960 Wells, 1958 Uphof, 1968

Cook and Keeland, 1962

CSIR India, 1972

Genest and Sahasrabudhe, 1966

Hofmann, 1971

Hofmann and Cerletti, 1961

Marderosian and Youngken,

1966 Taber era/,, 1963 Taber and Heacock, 1962 Uphof, 1968

CSIR India. 1976a Hakim *et a!.,* 1976 Martindale, 1977 Patil and Torne, 1980

during year.

List of plants tolerant of arid or semi-arid - Part 90

277. *Urginea maritima* I L.) Baker; syn. *U. tciHa* Stainh,,

***ScMa maritima* L.**

(Squill, sea on ion I

Mediterranean area, S. Africa.

A bulbous perennial which occurs as two varieties, red and white ('red squill' and 'white squill'L Both contain cardiotonic (heart stimulantl glycosides of the steroid (bufadienolide) type exerting digitalis-like action: the dried sliced bulb of the white variety, with the scales removed, li used clinically as a rapid-acting cardiotonic, diuretic and. particularly, expectorant; it is included in various pharmacopoeias. However, the red variety has additional constituents and shows very marked toxicity towards rats and other rodents (ascribed to the glycoside scilliroside) and is used as a rat poison, not clinically.

Main interest is as a source of cardiotonic glycosides. However, the bulbs 175% water) also contain, on a dry water basis, 74% carbohydrate, 2.5% fat and 7% protein; ethyl alcohol can be obtained by yeast fermentation of the hydrolysed sliced bulbs, with animal Feed and fertilizer as by-products. Anthocyanins (cyanidinand palargonidin) and various flavonqids (quercetin, kaempferol, etcj have been isolated from bulbs of the red variety. Can be propagated by seed or vegetatively from bulbs; the latter produces a crop two years Barlier. On measuring the comparative potencies of this and Indian squill I*U. indica; see* previous entry) the latter was 'found to be less potent. Red squill acts as a specific poison to rodents as other, e.g. domestic, animals reject it by vomiting.

The powdered drug is hygroscopic and should be stored in a dry atmosphere. Its clinical use can lead to severe side-effects and digitalis is usually preferred when a cardiotonic is required (major use is as an expectorant). The red variety is very irritant to the skin and must be handled with care.

Abdel Kader at1973 Anon, 1940 Balbaa era/,, 1979 Blanchard, 1972 Chevalier, 1953 Crabtree, 1947 Hakim er *a!.,* 1976 Karawya *et al,,* 1973 El Kiey *at at.,* 1964 El Kiey *eta!.,* 1960b El Kiey *eta!,,* 1967 Kubinyi era/., 1971 Martindale, 1977 Pantanelli, 1946 Uphof, 1968 Vega ***eta!.,* 1969 Vega era/., 1972 Wartburg, 1964 Wartburg, 1966 Wartburg *et a!.,* 1968**

List of plants tolerant of arid or semi-arid - Part 91

278. *Vernonia anthetmintica* Willd; syn. *Centratherum an rhelmin ricum* Kuntze

(Ironweed, Indian ironweed, purple fleabanel

India, S. America.

279. *Wiftard/a mexicana* (3. Wats.) Rose;

syri. *Coursetia mexicana* S. Wats. (Nesco, paio piojo)

Mexico,

List of plants tolerant of arid or semi-arid - Part 92

A perennial herb, used in some parts of I ndia for skirt diseases, leprosy and as an abortifacient; fruits are used for their anthelmintic activity. Seed is used in stomach-swells of cattle and as carminative for horses.

Shurb or tree growing in the Sonora/Chihuahua desert/semidesert areas of NW. Mexico. Wood used for mining props. Decoction of bark used against parasites on cows and horses.

The seeds contain 126%) an optically active (lit] -10.7°) oil, iod. val., 102 and with fatty acid composition: vernolic (12, 13-epoxy-octadec-9-enoic), 70/75%; accompanied by oleic, linoleic. and Ci4—Cia sats. Unsaponifiable fraction reported to be 6-79S of oil (high I and to include 10% stigmasterol, no brassicasierol (despite earlier reports) and 70% A? —avenasterol (the 7, 24(281 diene derivative of stigmasterol) and so may make a useful source of this Cjg unsat. sterol. The main interest is the vernolic acid, by far the major constituent, which is multi-functional as it stands, or after hydrolysis to dihydroxyoleic acid; it is a possible intermediate for the chemical industry. Also big demand for epoxy>oils in plastics industry, for protective coatings, etc. and expensive to synthesise so that this natural source should be very competitive. Tests with PVC show that vernolic acid esters make good plasticisers (better in some respects than the usual synthetics) improving its stability to heat and light; and that the crude oil makes a useful stabiliser (and after epoxidation of the remaining double bonds, plasticiserl. The amino-acid content of the seed [18% protein) has been measured.

Seeds contain 26% protein and 34% oil. Oil has iod. val.,

137, sap. val., 1 75; main constituent (50%) probably oleic. Extracts of bark, stems and wood show insecticidal activity; also said to toe effective against melon worm.

Plant is a legume and so should improve soil fertility.

Harvesting of seed made difficult by tendency to shatter (leading to high seed lossesi; seed dust contains a toxic bitter principle which necessitates careful handling during harvest and storage (perhaps requiring facemasks).

Asaka ef *a!.*. 1977 CSIR India, 1950 Earle *etat,,* 1960c Frost and Ward, 1968 Krewson ef *a!.,* 1966 Krewson and Luddy, 1964 Krewson and Scott, 1964 Mensier, 1957 FVincen, 1979 Princen, 1982 Riser « a/,, 1966 Smith *et at.,* 1959 Tiwari er*at.,* 1968 Trotter *eta!.,* 1962 Uphof, 1968 White and Wolff, 196S Williams, 1966

Botiger and Jacobson, 1950 Earle ef *at,,* 1962 Feuell, 1965 Jones and Barclay, 1972 Uphof. 1968

280. *Wtthania somnifera* (L.) Dunal (Ashwagandha {in India!) Mediterranean area, Africa, 5- Asia.

281. *Xantft/um commune* Britt, (jee also next entry)

ICocklebur)

Tropics and subtropics including arid regions (a.g SW. USA)

Similar (but enhanced) property exhibited by *W. coagulant* ('Indian rennet'), a xerophytic plant from the drier parts of Pakistan and NW. India, ascribed to a coagulating enjyme which is very active; used in India as a substitute for animal rennet to make cheese (CSIR India, 1976a).

List of plants tolerant of arid or semi-arid - Part 93

Perennial. Seeds used in Sudan to coagulate milk;* Decoction of root and bark used in local medicine since ancient times in, respectively, India {where known as ashwagandha} and parts of southern Africa; is listed, as a sedative, in the Pharmacopoeia of India; leaves used topically to promote healing of ulcers, abscesses, etc.

Small herbaceous annual; leaves used by American Indians in local medicine.

In India roots for medicinal use were originally obtained from wild stands but more recently a plant earlier assumed to be *W. sommfsra* has been cultivated to ensure regular supplies. It grows on soils unsuitable for other crops, requires no irrigation (except rain at sowing time) nor fertilizer. Yield 1 50 kg (sometimes 300) dried roots/faa. Roots contain many alkaloids (0.1 -0.3%; and responsible for the roots' pharmacological activity), along with starch and other carbohydrates, waxes, etc. and also two C_2a steroids known as withanolides. A large, though variable |s#e Constraints), number of the latter compounds, which are characterised by the presence of a lactone ring in the side Chain, occur in the leaves of *W. somnrfera* and are thought to be responsible for their healing powers. The most important is withaferin *A,* of icnown structure, and readily isolated (0.18% yield; said to be higher in African plants) from the leaves: it shows antibiotic, ami-inflammatory (competes in activity with hydro-cortisone I and ant'r-tumour activity — and its use has been patented. Its **antibiotic activity depends on its unsaturated side-chain lactone and is destroyed by reduction Or hydrolysis. Berries have unusually high free amino-acid content (due to presence of a proteolytic enzyme). Plant said to have insecticidal activity.**

Solvent extraction of seed yields, depending on solvent used, 4.6—7.5% oi); iod- vsl. ranging from 44.6—103 and density (at 25°C), 0.894-1.009. Reported that the oil [can be used in paints and varnishes' (but barely as a drying qil presumably) ■

The main interest is in the roots and so the whole plant has to be harvested and fresh plant raised from seed. Some doubt as to whether Indian wild and cultivated plants have same activity/constituents — or indeed are same species. Also wide variation in constituents of wild stands with geographical location: identifiable 'chemotypes' of the species characterised by their withanolide content and type; complicates possible exploitation. Withaferin A's instability to alkali should be considered in isolation/ purification procedures.

Typical, and inactive, plant sterols Icampesterol etc.) produced in tissue cultures of *W. samnifer#* rather than withanolides.

Atal and Schwarting, i960 Atal and Schwarting, 1961 Bhatnagar *etai.,* 1961 Chakraborti *etal*.. 1974 CSIR India, 1976a Duisberg and Hay, 1971 Fontaine and Erdos, 1976 GI otter *et ai,* 1973 Jacobson, 1975 Kirsonefa/., 1977 Uphof, 1968 Yu *et ai.,* 1974

Duisberg and Hay, 1971 Krochmal *etai.,* 1954 Tussingand Dunbar, 1335

282. *X^nthium strumtrium* L, (Same vernacular name and generally similar to {? syn. with! *X. commune)*

(Cocklehur)

Native of S America; now wide spread in the tropics, naturalised 'in the hotter parts of India'. Cultivated in China.

283 *Xafithocephalum serothrae* (Pursh) Shinners, syn, ***Gutierrczia sarothrae* (Pursh) Britt.** 8L RuSBY

IBroomweed, matchweed, snakeweed) SW. USA, Mexico.

List of plants tolerant of arid or semi-arid - Part 94

A coarse annual up to 1.5 m high; young leaves used as a vegetable, mature leaves used as a green manure. Decoction of leaves widely used in various local medicines.

Aqueous extract of plant material used in traditional medicine and is sometimes used Ss a forage for sheep and horses.

Aerial parts contain various alkaloids and sesquiterpene lactones, some with pharmacological activity. Seeds yield (27% by pressure; 30-41 % by solvent! a semidrying oil, resembling sunflower oil, with iod. val., 112-142, fatty acid composition; oleic, 22—37%; linoleic, 52-S7%; sats., 10-16%; unsap, fraction, 0.37 -1.3%. Could make a useful oil for inclusion in paints, varnishes and alkyd reiins. Oil also contains relatively high percentage of phosphatides and has been suggested as a source of lecithin. The residual oilcake is rich in N and P and makes a good fertilizer (10% N, 3.5% dry wt basis! The

fruits are rich in vitamin C (47 mg/IOGg) and the seeds in iodine.

Seeds contain protein *222%,* oil 31 .8% (? a possible oilseed). Aqueous extract of plant material found to contain an anti-tumour, proteinaceous substance.

Seeds and the uncooked (especially youngl leaves are toxic, e.g. to browsing animals; similarly the oilcake. Seeds difficult to remove from fruits. Chemical composition varies widely. Tends to become an uncontrollable weed (via burrs, catching on wandering animals and on clothingl.

Very aggressive plant in its natural habitat (?difficult to control).

CSIR India, 1976b

Watt and Breyer-Brandwijk, 1962

Benson and Darrow, 1944 Jones and Barclay, 1972 Krochmal and Krochmal, 1973 Ulubelen *et al.,* 1965

234. *Ximenia americana* L .; syn.X. *spina&a* Salisb.

(Wild olive, Mild lime, tallow wood, hog plum, spiny plum, tallow nut, beach plum, false sandalwood) Widely in the tropics and subtropics including some of the drier areas {Sudan, Deccan peninsula of India, etc.)

List of plants tolerant of arid or semi-arid - Part 95

A spiny shrub, 4—5 m tall, which grows on very poor land. Yields a good wood, sometimes used as a substitute for sandalwood.

Fruits (and seeds) eaten widely and also made into jam and jelly. Seeds boiled with water yield a fat used in S. India as a substitute for ghee; also in some countries has cosmetics uses. The fruits resemble limes, but the juice is sweeter and more insipid; used in S. Africa to make a kind of beer, The seed oil is used to make soap and candles and as a lubricant, but is not competitive with other oils. Wood contains an essential oil and is used for fumigation in Ethiopia. Crushed leaves smell of bitter almonds and are used as flavouring in Indonesia. The bark contains 17% tannin and an insect repellent, and extracts are used as an astringent and disinfectant. The fruits, seeds and roots feature in various local medicines.

The seed has a high (68—7594) oil (fat at normal temperatures) content but when obtained by expelling is yellow, viscous and mucilaginous;cleaner product obtained bv solvent extraction. Oil characterised by the presence of unusually long-chain acids [7 possible industrial use). Thus petroleum extraction yields (62%) an oil with iod. vaL, 85 and fatty acid composition: oleic, 49% total (sat. and mono-unset.)

C24-acids, 5%; C2&-acids, 7%; C28~acid£, 14%; C30, 5.5%; the acetylenic acid ximenynic acid (the acetylenic analogue of oleic with in addn a A^{11} C"C; with alkali, gives the conjugated triene acid), *G%;* and its 8-hydroxy deriv., ^10%, Unsap. fraction. 1,7%. Roots rich in acetylenic fatty acids.

Rubbery material in the oil (especially when expelled) makes it difficult to use; and it is a non-drying oil. Both seed and oil may be toxic in even moderate quantities due to present of a cyanide-producing principle which occurs in varying amounts depending on location, etc. {hence deceptive). The oilcake is unsuitable as a feed — has purgative action. There are richer sources of the principal acetylenic acid (ximenynic) elsewhere: e.g, *Osyrisatba,* entry no. 223, has 57%.

Anon, 1935 Anon, 1936 Burkhill, 1935 Coursey, 1964 **CSIR Inida,** 1976**b Earle *etet.,* 1960b Fanshawe, 194S Freise, 1936 Freise, 1938**

Grant and Williams, 1936 Gurney and Francis, 1940 Lighthelm, 1954 Lighthelm and Schwartz, 1950 Mensier, 1957 Mikolajczak ef a/., 1963 Uphof. 1968 Vaughan, 1970 Williams, 1966 Willis and Shaw, 1973

265, *VucCaS — general comments*

(The same common, or local, name frequently given to more than One species (e.g. 'soapweed'))

Deserl and semi desert areas of SVV. USA and N Mexico.

Yuccas are commonest in sand and gravel soils. Early and present day uses of yuccas in general are locally for food, in beverages and as a crude 'SOap' (detergent) (due to the saponins present), for clothing, in construction of dwellings and household art icles. Most extensive use is for fibre. Juice used as *a* base in liquid fertilizers.

A major recurring interest has been the isolation of saponins, and hence sapogenins, as precursors of steroids (of both the cortisone and contraceptive-pi II types) from the leaves and/or seeds as by-products to fibre extraction. Another possibility is the extraction of oil and protein from the seeds; and some *Yucca* spp. are said to have a high vitamin C content.

Average wild stand of yuccas too small for large^cale economic exploitation; cultivation would be necessary (even then except when e.g. war cuts off normal fibre supplies not likely to be worthwhile!. No area bearing less than 200 kg fresh leaves could be harvested profitably *Yuccd* spp. generally grovu very slowly and need at least 3—5 years to produce worthwhile new growth after cutting, and they flower, and set seed, irregularly, Obtaining maximum sapogenin yield may require allowing the endogenous enzymes to act on the glycosides first, at neutral pH, before treating with acid. Demand for sapogenirts as steroid precursors (being those given in footnote* to entry no. 7} has waned: *see* entry no. 111,

Anon. 1955a Arnon, 1972 Blunden et 0/., 1965 Cruse, 1973 Duisberg, 1952a, b Duisberg and Hay, 1971 Hernandez, 1970 Kirby. 1963 Krochmal era/,, 1954 Paris and Oilleiriann, 1960 Webber, 1953

286. *Yucca afUonica* McKtrlvey[1] Arizona.

287. *Yucca baccata* Torr.f

(Pita, [iatil, bayonet yucca, soapweed, banana yucca)

S, USA, Mexico,

Woody plant: Fruits are eaten cooked, fresh or dried by Indians and Mexicans; and the fresh flower buds eaten. Fibres used for basketry, mats and various tying purposes. Flowers a possible source of perfume

Seeds have one of the highest sapogenin contents recorded — 1 2% sarsdsapogenin (dry wt.) and this can be converted chemically into cortisone.

Fruits a rich source of sugars. Some of the Strongest yucca fibre known comes from this species: said to be comparable with Manila hemp. Seeds fairly high 16.8%) in sarsa-sapogenin (s« previous entryl.

Wall and Fenske, 1961 Webber, 1953

Benson and Darrow, 1944 Duisberg, 1952b Krochmal eta/., 1954 Latorreand Latorre, 1977 Uphof, 1968 Wall and Fenske. 1961 Webber, 1953

*** *See* (also) constraints noted under first entry on *Yuccas.***

^ Concerning varieties and tendency to hybrid formation, see Webber, 1953.

List of plants tolerant of arid or semi-arid - Part 96

Citation data

Constraints

288. *Yucca brevifotia* Engelm.

(Joshua tree, tree yucca, cactus-yucca, yucca palm)

Utah, Arizona, California, Nevada,

239. *Yucca carnerosana* (Trel.) McKelvey;

syn. *Samueta carnerosana* Trelease

(Palma samandoca, palm barretta) Mexico, Texas.

A small tree growing in extensive open 'forests' at

1,000-2,000 m. Cattle and

sheep eat the flowers (but which, though nutritional, have a soapy taste - due to the saponins). An extract of the plant is used in the production of root and ginger beer, having a great foaming quality, and marketed as 'Brevifoline' *[see* also entry no. 295).

Unbranched thick trunk up to

6 m high crowned with a rosette of long narrow leaves; thrives on calcareous soils from valley bottoms to mountain crests (3,000 m). Fibre fixtie de palma) obtained from the inner leaves of the rosette has properties and uses as *for Agave fechagui/ls* (fee entry no. 11) fibre though less popular sinoe more difficult to work, Can also obtain a kraft (brown) paper from the pulp. Again, residues can be used for soap. Trunk of plant especially useful in constructing walls of buildings and fences.

Can be used for newsprint cellulose. Unusually large content of sapogenin (8% tigogenin) in seeds. Wood has small amount of smilagenin. Seeds and dry pods would make good feed materials. Seeds contain 34% oil which is semi-drying (iod. val., 120), edible and may have other uses. Wood possibly valuable in manufacture of vanillin Iby oxidation of the 9% lignin thereinl.

Very low (compared with other Beggs, 1949

Plant has relatively long life span for a yucca (50—75 years). The fibre has similar potential to that of *Agave lechegviils* but is slightly less sought after.

***Yucca* spp.) sapogenin content in leaves. For exploitation of the seed sapoganins to be economic (in competition with *Dioxorea,* etc. sources), large quantities of plant material would have to be available and collection costs low*.**

Grows wild at rather low densities — hence collection problems. Although fibre is similar to that of *A.* *iBCheguilla,* the latter is preferred since is cleaner, easier to work and more durable. Similarly, the soap substitute is also inferior. (Despite this still has an important role in life of the rural poor of N.C. Mexico I .*

Cruse, 1973 Duisberg, 1952b Wall and Fenske, 1961 Webber, 1953 Woodbury *et al.,* 1961

Ridaura-Sani, 1979 Sheldon, 1980 Webber, 1953

The seed yields (26%) an oil with iod. val., 128, hence a semi-drying oil, containing 63% dienoic (?lino)eic) and 24% monofinoic l?oleicl fatty acids.

290. *Yucca const ncta* Texas,

Agronomic research required before cultivation as economic crop *,

Cruse. 1973 Earle *at at.,* 1960b Webber, 1953

' *See* (also) constraints noted under first entry on yuccas.

List of plants tolerant of arid or semi-arid - Part 97

291. *Yucca* etera Engelm.

{Palmella, soapweed, soaptree, beargrass)

SW. USA, Mexico,

292, *Yucca fiiamentosa* L.

(Common yucca. Eve's thread, Adam's needle)

N. America: has been introduced, as an ornamental, to India.

293. *Yucca filifer a* Chab, Mexico.

*** See (also) constraints noted under first entry on yuccas.**

List of plants tolerant of arid or semi-arid - Part 98

Small tree. Roots used locally as soap for washing clothes and leaf fibre as cordage and also woven into mats and cloth. On a larger scale, the fibre has been used as a substitute For jute around bales (during World War II, for making mattresses, and to make speciality paper in the USA. The whole plant has been used as an emergency cattle feed during drought (after manual or mechanical chopping up and mixing with e.g. cottonseed meal) with no apparent ill-effects.

Perennial coarse herb. Fruits eaten by the local Indians. Roots used as a crude soap; macerated leaves as fibre {said to be one of the best yuccas for fibre) and the point as a needle; central spike used 34 a vegetable as also other parts of shoot. Saponins have been extracted from the roots.

One of the most abundant *Yucca* spp. in Mexico (in alkaline sandy-clay). Leaves are used locafly as a roofing material and as a source of fibre for making brushes and papef pulp.

Seeds contain (dry wt.) 0.9% sarsasapogenin and 29% of a semi-drying oil, iod .val., 128, fatty acid composition: linoleic (probably), 52%; oleic, 32%; sets., 9%; epoxyacids, 6%, Legvss contain 40/45% dry wt, fibre of similar strength to sisal and is, with that from *Y. gtauca,* usually considered one of the two most commercially attractive yucca fibres. A root extract has been mooted a: a possible foaming agent for beverages: see entry no, 295.

Thrives on 350 mm rain p.a, Seeds rich source of sarsasapogenin (see entry no, 286) and contain 20% semi-drying oii (iod. val., 135) which, after epoxidation, can be used as a plasticiser. Field studies in 1956 indicated adequate wild stands to feed a cellulose — extraction plant.

Very low sapogenin content; epoxy-fatty acids may cause toxicity problems*.

A cellulose-extraetion plant established in 1956 was not successful and the original stands of the yucca have been cleared. Problems with large-scale propagation, as required for commercial production, especially with seed propagation {variable seedling characteristics) *,

Very slow growth (flowers/ seeds only after 30+ years) and lack of information created doubts. Meanwhile stands are being destroyed for agriculture.*

Cruse, 1949 Cruse, 1973 Duisberg, 1952b Earle et *a/,,* 1959 I sen berg, 1956 Jones and Conner, 1918 Kirby, 1963 Uphof, 1966 Wall and Fenske, 1961 Webber, 1953

Cruse, 1949 CSIR India, 1976b Czaja, 1951 Czaja, 1957 Hernandez, 1970 Kirby, 1963 Uphof, 1968

Blunder ef *at.,* 1975 Gentry, 1972 Hernandez, 1970 Ridaura-Sanz. 1979

294. *Yucca glauca* N utt.

(Small soapweed, beargrass, Great Plains yucca)

SW. USA, Mexico, Pakistan.

295. *Yucca schidigera* Roeil ex Ort, syn, *Y, mohavBnsis* Sarg.

(Mohave yucca)

Arizona, California.

296. *Yucca schottii*Engeim.; syn. *Y. macrocarpa* Engelm.

(Mountain or hoary yucca, sword cactus)

Arizona, New Mexico.

A low shrub which tolerates salt. Roots used locally bs a soap for washing clothes (and young stems, the central spike, flowers and seed pods as foods). The leaves have been used on a large scale as a source of fibre for burlap and bagging (40,000 tonnes during World War I), as a jute substitute around bales (also in World War I) and to make a heavy-duty kreft (brown) paper used in construction etc (especially during World War II). Has also been used like *Y, elata* as an emergency cattle feed.

Woody plant: leaves have been used (e.g. during World War I when other fibres were scarce) as a source of fibre — which is similar to that from *Y. baccara* though slightly softer and weaker. A concentrated aqueous extract of the leaves is widely used as a foaming agent for soft drinks in the USA.

1.5-2,0 m tall; grows at

4,000-7,000 ft (1,2002,100 m) altitude.

Seed yields 127%) an oil with lod. val. 142: hence a potentially useful semi-drying oil for use in paint; etc; main fatty acid constituent (69%) dienoic (? linoleicl acid. Dried leaves have 40/45% fibre — which has almost the tensile strength of jute. With *elata,* this is one of the two *Yucca* spp, fibres usually considered to have commer cial possibilities. Sarsasapogenin (around 1%dry wt.: *sea* entry no. 286) with smaller amounts of several other sapogenins isolated from seeds.

A toxicological study of the foaming agent showed no <*n vivo* haemolytic activity nor any other adverse effect. Seeds contain 6.6% sarsasopgenin (we entry r>o. 286).

Sarsasapogenin content of seeds, 4.9%

1961

Commercial production ceased due to slow plant growth and to difficulties with retting (extracting the fibre)[11].

Cruse, 1949 Cruse, 1973 Duisberg, 1952a, b Earle *eta!.,* 1960b El-Olemy *et at,,* 1974 Jones and Conner, 1918 Kirby, 1963 Wakil and Khan. 1975 Webber, 1953

Cruse, 1973 Oser, 1966 Uphof, 1968 Wall and Fenske, 1961 Webber, 1953

Wall and Fenske, Webber, 1953

*** *See* (also) constraints noted under first entry on yuccas.**

List of plants tolerant of arid or semi-arid - Part 99

297. *Yucca whipptei* Torr.

{several sub-species and varieties known)

svn. *Hesparoyucca whippfe (Torr,) Baker.**

{Our-Lord's-candle, Chaparral yucca, Quixote yucca]

California, Arizona, Mexico.

298- *Zizyphus Obtusitfoiia* [Torrey

4 Gray) A. Gray

Texas, Mexico.

Leaves used on a small scale as a source of a long white fibre similar in texture to, and nearly as strong as, henequen. Flowers and seed used locally as foods.

A spiny tree, adapted to deserts. Fruits are eaten and have an agreeable taste (slightly 'puckering'). Used by the Mexican 1 ndians.

Tigogenin content of seeds, 1 .9%; leaves contain 1% sapogenin {mainly tigogenin). Seeds have high Oil **and protein content and leaves abundant cellulose content.**

The seeds contain 21.5% protein and 28.8% oil. Other species of the genus, in other parts of the vvorld, are used as a source of drugs, tanning materials, alkaloids, timbers, dye, fish poison, cattle fodder, *Z. mauritiana* and *Z. spina-Christi* mentioned as potential firewood species by the National Academy of Sciences (1980).

Relatively low sapogenin contents*.

Bender, 1963 Wall and Fenske, 1961 Webber. 1953 Uphof, 1368

Chevalier, 1947

Jones and Barclay. 1972

Latorte and Latorre, 1977

*** See (also) constraints noted under first entry on yuccas.**

List of plants tolerant of arid or semi-arid - Part 100

'> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

Home"

1 Plants Tolerant of Arid, or Semi-arid Conditions and with Non-food Constituents of Potential Use (NRI)

B *(introduction...)* **1! Acknowledgements II Introduction**

D Section 1: List of plants tolerant of arid or semi-arid conditions with non-food constituents of potential use D Section 2: References

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